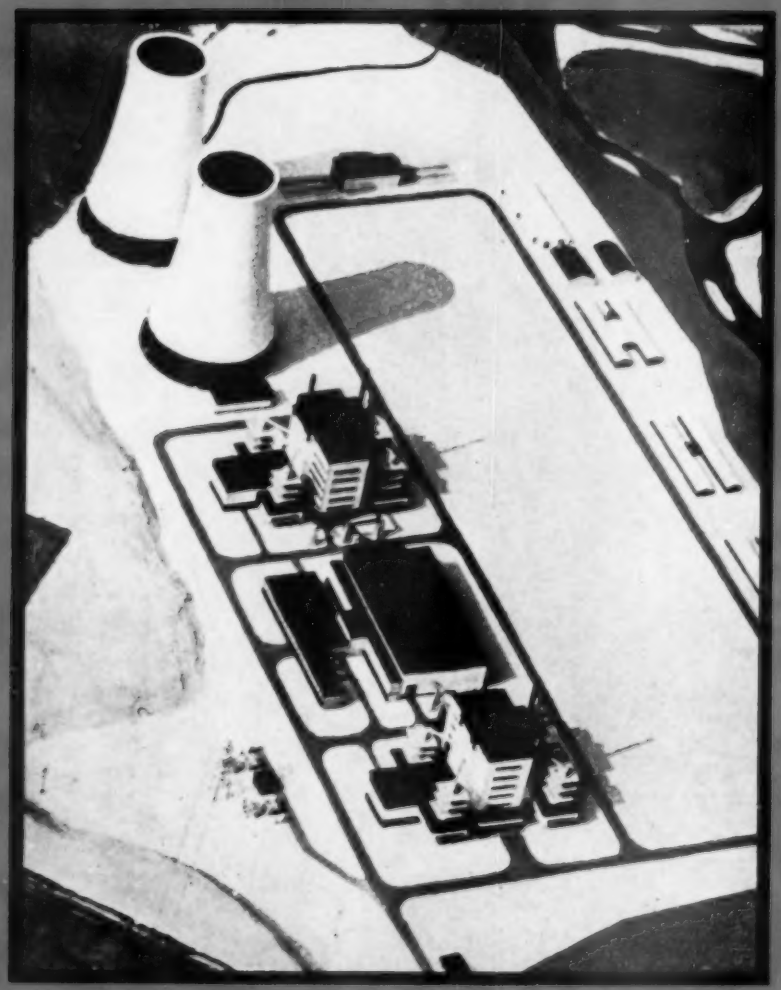
COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

January 1956



Final model of Calder Hall Station, England's first Atomic Power Plant

Projected Cost Outlook for Conventional Power

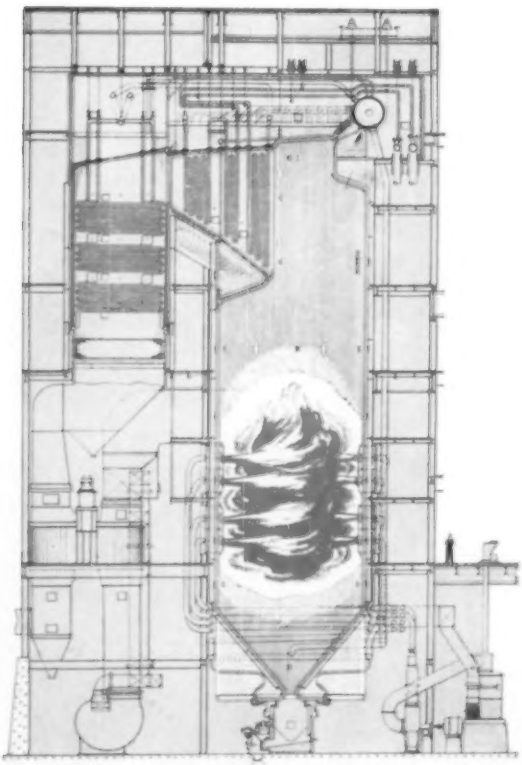
Power Practices in 1955

Nuclear Engineering and Science Congress

THE BURNER WITH A BRAIN

Automatically the C-E Vertically-Adjustable, Tangential Burner nozzles tilt downward. More furnace wall surface becomes effective. Gas temperature to superheater is lowered. *Steam temperature comes down.*

Conversely, if steam temperature drops below that most efficient for the turbine, burner nozzles tilt upward, sending hotter gases to the superheater—*automatically.*



RESULT—less need for desuperheating . . . minimum use of spray water . . . less chance of fouling turbine blades. Turbine availability is higher . . . efficiency is maintained.

Modern, high-pressure, high-temperature power generating units need the highest quality steam possible. That's exactly what they get with C-E Tangentially-fired Boilers.

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BOILERS, FUEL BURNING & RELATED EQUIPMENT; PULVERIZERS, AIR SEPARATORS & FLASH DRYING SYSTEMS; PRESSURE VESSELS; AUTOMATIC WATER HEATERS; SOIL PIPE

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

Vol. 27 **No. 7**

JANUARY 1956

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BPA

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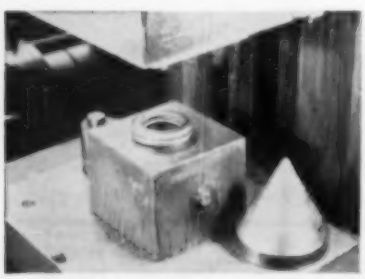
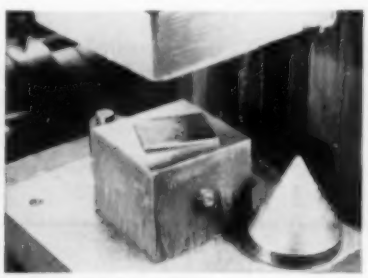
These extras make ELECTRUNITE

	TESTS	ELECTRUNITE BOILER TUBES	ASTM A-178 ASME SA-178	ASTM A-226 ASME SA-226	A.A.R. M-108	SEE NOTE*	FEDERAL WW-T-731b	MIL-T-17188	MIL-T-20160	MIL-T-20162 MIL-T-20169
Before Welding	Chemical Composition	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Gage Check	✓								
Production Control	Flattening	✓								
	Reverse Flattening	✓								
	Expansion	✓								
	Flange	✓								
	Metallurgical Laboratory	✓								
Finished Tube	Flattening	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Flange	✓	✓	✓	✓	✓	✓	✓		
	Crush	When required	When Required		When Required	When Required				
	Reverse Flattening	✓	✓	✓		✓				
	Tensile	✓							✓	✓
	Hydrostatic	✓	✓	✓	✓	✓	✓	Optional	✓	✓
	Non-Destructive Electric	When required	In lieu of Hydrostatic	In lieu of Hydrostatic			In lieu of Hydrostatic	All or part required		Optional
	Final Inspection	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Protective Coating	✓					✓	✓		

*NOTE: Tests in this column specified in American Bureau of Shipping, Sec. 40 par. 66-83; Treasury Dept., U. S. Coast Guard-Marine Engineering Regulations 51.01, 51.25, 51.28, 51.34.





THESE TESTS ARE TYPICAL of those listed in the chart above, showing: 1, axial crush test; 2, flatten test with weld at point of maximum bend; 3, hydrostatic test of each completed tube, at a pressure in excess of code requirements.

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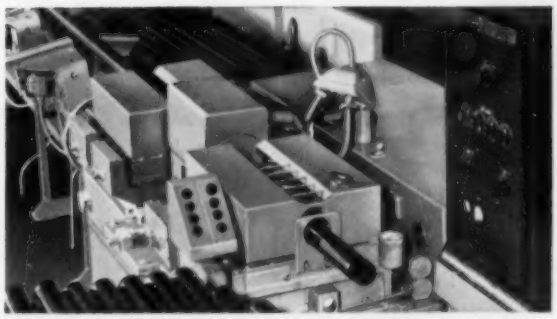
World's Widest Range of Standard Steels

...the most thoroughly tested tubing you can buy

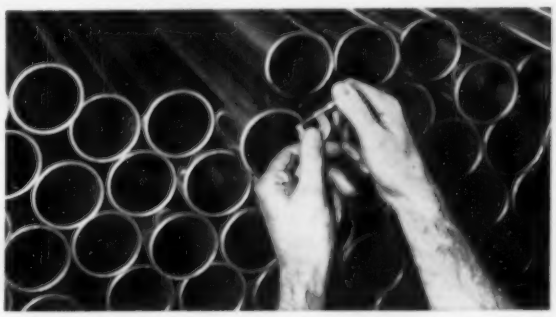
Let's face the facts: the true test of boiler tubing is its performance in actual service . . . but you have to know the results before installation. That's why Republic ELECTRUNITE® Boiler Tubes are your best choice, whether you are installing a new boiler or retubing an existing unit. ELECTRUNITE, the original electric resistance welded tubing, is backed by more than a quarter century of manufacturing experience plus the most thorough quality control and testing program in the world.

This program assures quality from raw ore to finished product and includes not only all tests required by applicable specifications (see chart), but *complete production control tests* during manufacture, as well. In addition, Republic alone offers FARROWTEST®, the electronic nondestructive test, which, when you specify it, peers *inside* your tube walls to detect and reject any flaws. Republic quality, verified by FARROWTEST, will meet the strictest specifications. It is your best evidence that ELECTRUNITE Boiler Tubes, when properly installed and maintained, will give years of dependable, trouble-free service.

On your next order for boiler tubes, get the best. Get Republic. Just call your local Republic representative or mail the coupon for further information.



FARROWTEST . . . DEVELOPED BY REPUBLIC is the most conclusive, nondestructive tubing test in use today. Electronically operated, its detector coils can spot defects in tube walls which would be hidden from routine test procedures. You can specify FARROWTEST on ELECTRUNITE Boiler Tubing instead of your present method at no extra cost.



UNIFORMITY IS THE KEY to easier, faster installation when you use ELECTRUNITE Boiler Tubes. They slide into headers and drums easily, expand evenly with less rolling, and bead over quickly. Republic manufacturing methods "build-in" uniform wall thickness, diameter, strength, ductility, microstructure and surface. Testing verifies these characteristics in each tube you receive.

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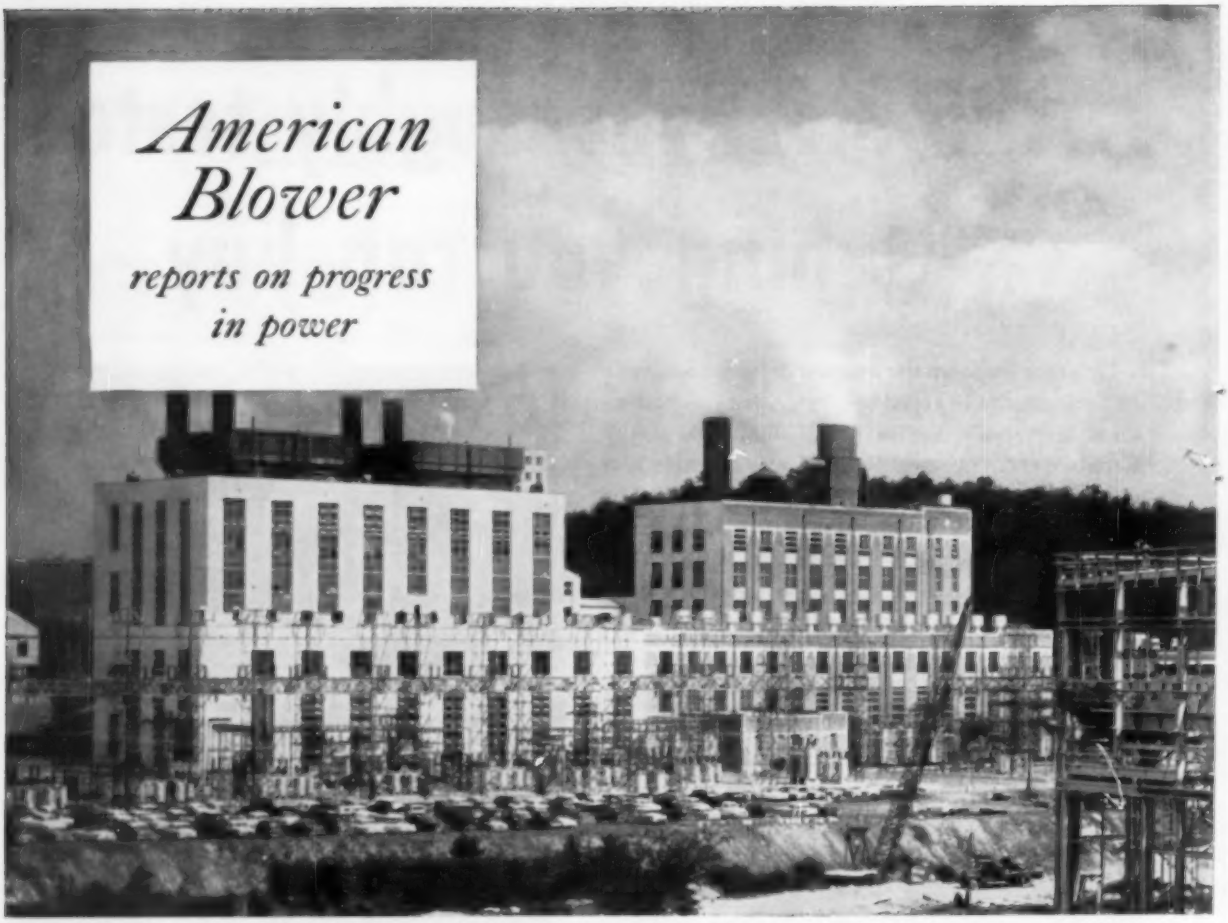
STEEL

and Steel Products

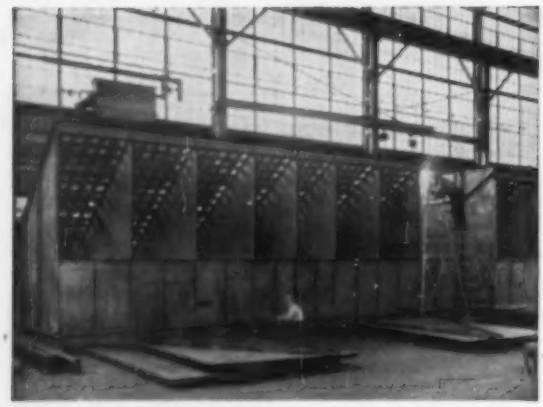
American Blower

reports on progress in power



Gorgas Steam Plant No. 2, with 428,000 hp capacity, is on the Warrior River. Plant No. 3 (right), under construction, will house

Alabama Power ups capacity to



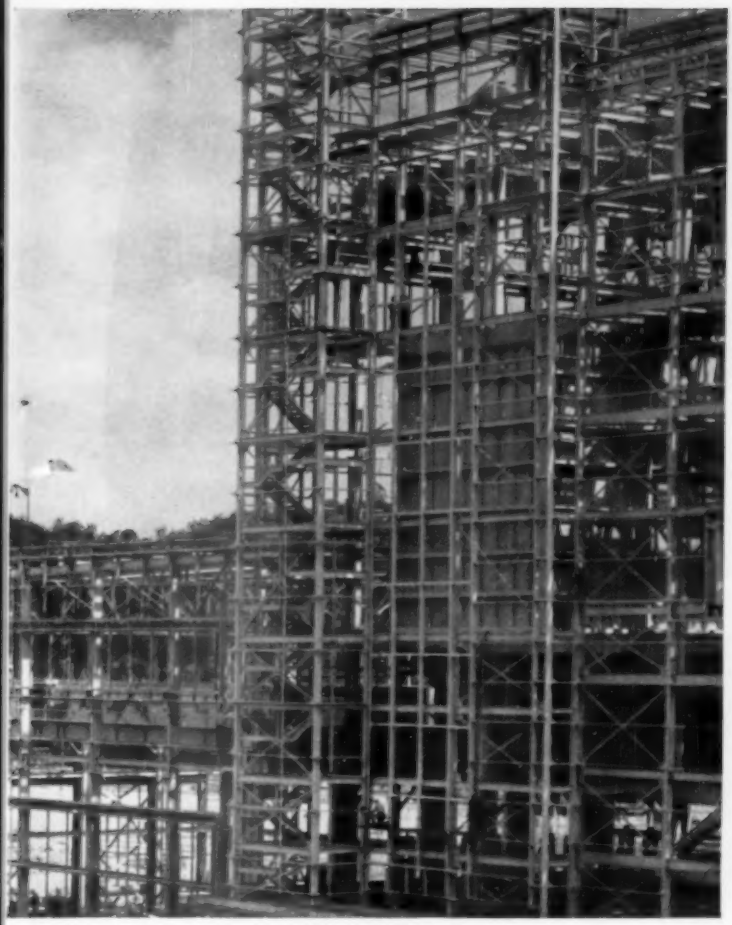
While Gorgas Steam Plant No. 3 is being built, American Blower constructs two Fly Ash Precipitators which will be installed in this new plant. Ratings: 340,000 cfm @ 285° F.

As in the past, Alabama Power installs American Blower equipment—in building for the future

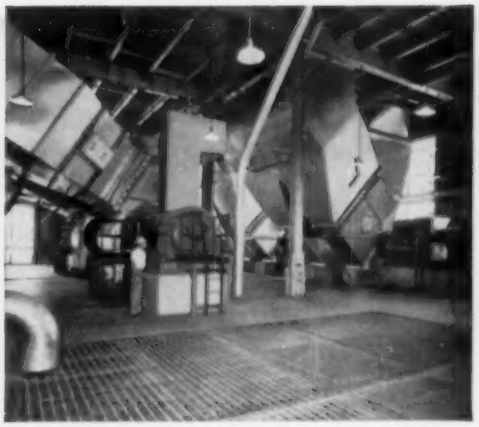
With six steam and six hydroelectric plants, the Alabama Power Company forges ahead for the future of Alabama. In 1955 alone, it will invest more than $35,000,000 in bigger and better electrical facilities, including an eighth generating unit at their Gorgas Steam Plants. When completed this year, Alabama Power's capacity will be over 2,000,000 hp!

American Blower Forced and Induced Draft Fans, Fly Ash Precipitators and Gyrol Fluid Drives are being installed in this new plant.

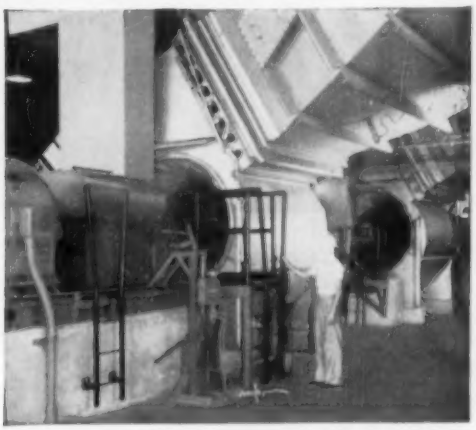
From coast to coast you'll find American Blower playing an important role in the expansion and modernization of many other progressive, investor-



No. 8 generating unit, rated at 208,000 hp.



Gorgas Unit No. 7 uses American Blower Fans with Gyrol Fluid Drives. Induced Draft Fans (above) are rated @ 262,500 cfm @ 270° F @ 15.25" sp @ 569 rpm.



American Blower Forced Draft Fans on Unit No. 7 at Alabama Power's Gorgas Steam Plant are capable of 180,000 cfm @ 140° F @ 11.00" sp @ 868 rpm.

over 2,000,000 hp!

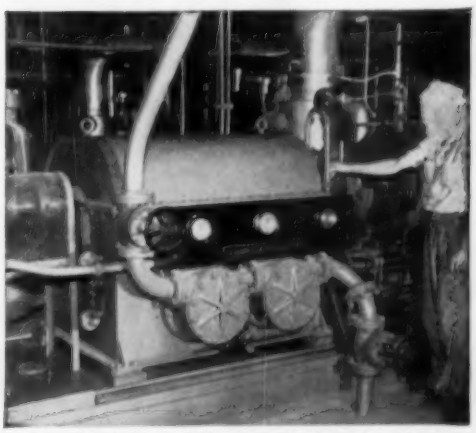
owned utilities. Plant operators have come to rely on American Blower Heavy-Duty Steam Coils and Fly Ash Precipitators, as well as our Mechanical Draft Fans, Dust Collectors, and Gyrol Fluid Drives for boiler-feed pump and fan control.

Give us a call to discuss *your* program. An experienced representative will gladly go over your requirements, and recommend equipment of the highest efficiency and economy. Contact your American Blower or Canadian Sirocco Branch Office.

AMERICAN BLOWER CORPORATION, DETROIT 32, MICHIGAN
CANADIAN SIROCCO COMPANY, LTD., WINDSOR, ONTARIO

Division of American-Standard

AMERICAN 75 ANNIVERSARY YEAR **BLOWER**

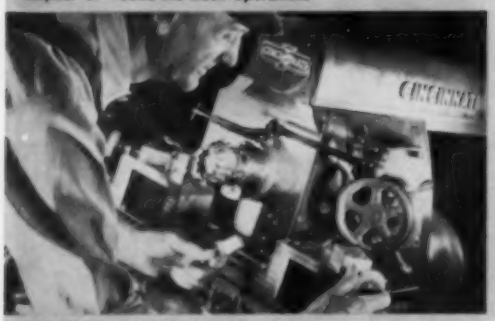


In addition to fan control, American Blower Gyrol Fluid Drives – class VI, 1500 hp – are used for adjustable speed control of boiler-feed pumps.

SOUND DESIGN—Richardson Engineers are career men in the design of automatic weighing equipment for all industries. Experience in thousands of field installations is reflected in these machines.

SCALE FABRICATION—Adequate shop facilities and trained workers are "musts" for the fabrication of a quality product.

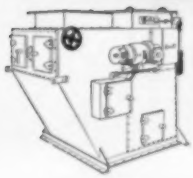
WELDING—Good welds, like these, are the true test of high quality workmanship . . . can withstand the year in, year out impact of 'round-the-clock operation.



PRECISION MACHINING—Knife edges, the heart of the weigh beam insuring long-term accuracy and dependability, are produced on this modern milling machine.

What goes into a Richardson COAL SCALE *Besides* COAL?

Here are evidences of the careful engineering and painstaking workmanship that go into every scale, every product manufactured by the Richardson Scale Company. Richardson stands behind its product . . . protects you with sound design, rugged, heavy-plate construction and competent nationwide service. That's why you can specify Richardson Automatic Coal Scales with complete confidence!



In the Power Industry, Richardson Coal Scales have earned a superior reputation for dependability. Send for Bulletin 0352 . . . and learn why.

Richardson

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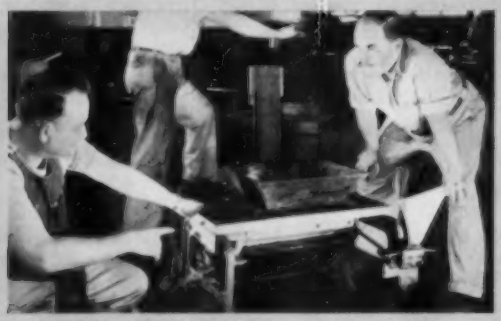
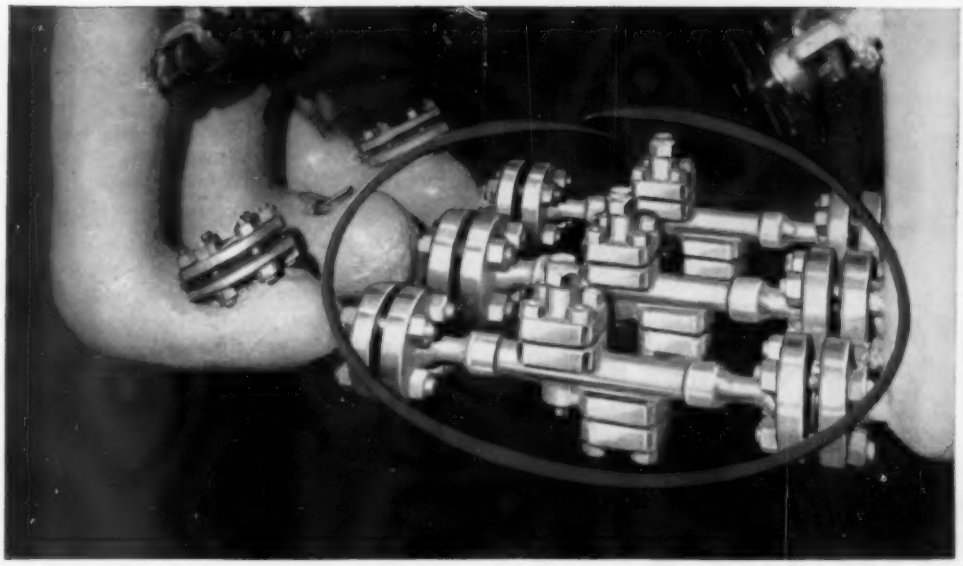
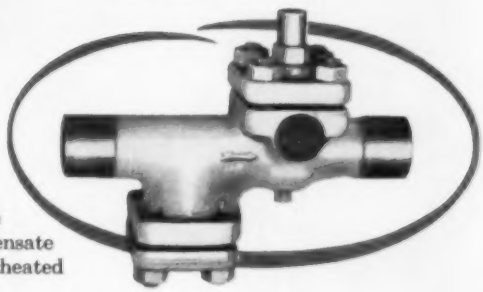


CUSTOMER SERVICE—A large, competent Richardson field-service organization . . . with an office near every installation . . . is another important reason to specify Richardson!



Three Yarway Integral-Strainer Impulse Traps draining main steam lines in large mid-west power plant. Other Yarway traps drain extraction lines in same plant. Yarway Integral-Strainer Impulse Traps are available with welding or flanged connections. Pressures 600, 1500 and 2500 psi.

HIGH STEAM PRESSURES AND TEMPERATURES CALL FOR YARWAY INTEGRAL-STRAINER STEAM TRAPS



YARWAY Integral-Strainer Impulse Steam Traps drain some of the hottest steam lines in the country—temperatures up to 1000° F and pressures as high as 2500 psi.

When system is being warmed up these traps have ample capacity, yet will handle relatively small amounts of condensate without losing prime . . . and in the presence of dry or superheated steam, the trap valve snaps shut.

Leading utilities and other high pressure steam plants appreciate the other YARWAY advantages, too, such as *small size, light weight, steel construction, easy maintenance.*

For complete description write for Bulletin T-1740.

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THERE'S A YARWAY IMPULSE STEAM TRAP FOR EVERY TRAPPING NEED

SERIES 60 and 120

For all *normal trap requirements,* pressures to 400 and 600 psi.

½" No. 20-A

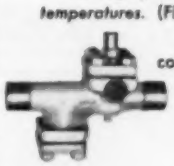
For light loads on tracer lines, steam mains, small presses, etc.

SERIES 40

For heavy loads requiring extra high capacity steam traps.

INTEGRAL-STRAINER HIGH PRESSURE TRAP

For high pressures, high temperatures. (Flanged or welding connections.)



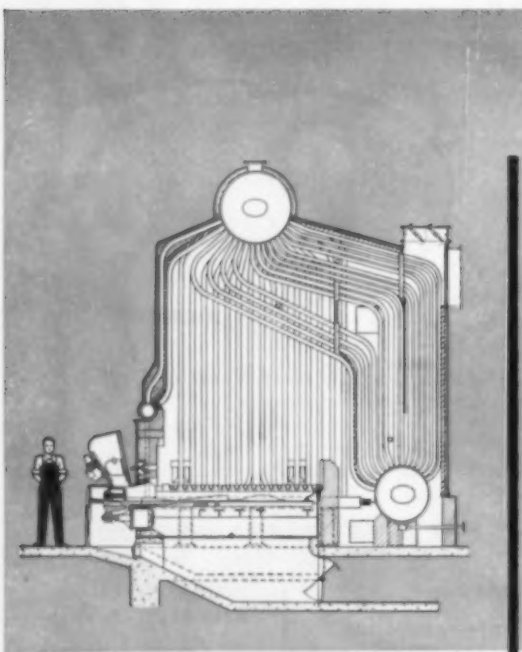
YARWAY IMPULSE® STEAM TRAP

OVER 1,000,000 YARWAY IMPULSE STEAM TRAPS USED

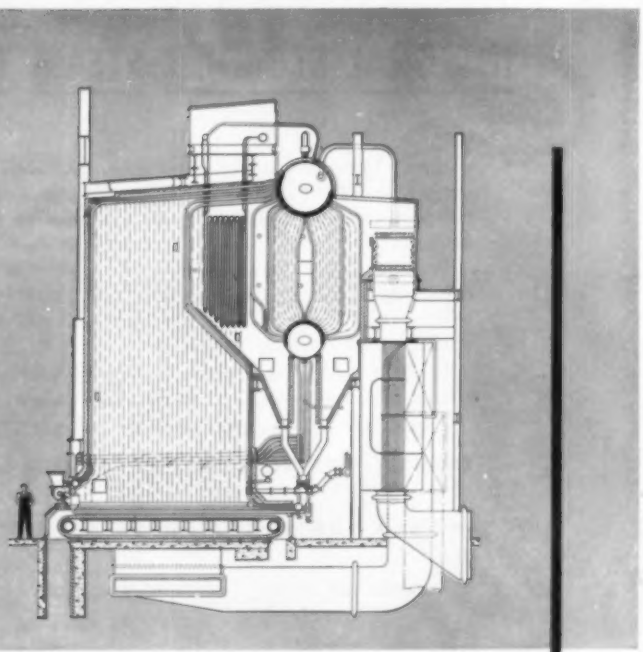
MODERN STOKER-FIRED BOILERS

Despite the relatively wide extent to which oil – and gas – have come into use for firing industrial boilers, the fact remains that coal continues to be the most economical fuel available in many areas.

Moreover many potential coal users are unaware of the tremendous improvements that have been made in recent years in the design and general effectiveness of mechanical stokers. Here at Combustion virtually the entire stoker line has had extensive design changes, all directed at improved performance. But overall performance is tied in inescapably with boiler performance. At Combustion you have the important advantage of dealing with a leading boiler manufacturer that also offers the most complete line of stokers available anywhere. You are assured, therefore, of a completely coordinated design comprising



This C-E Vertical-Unit Boiler, Type VU-10 fired by a C-E Underfeed Stoker, Type E is for a dairy. Capacity is 30,000 lb steam per hr at 150 psig. VU-10 Boilers are available for capacities from 10,000 to 60,000 lb of steam per hr. They are often equipped with C-E Spreader Stokers, dump grate type.



One of two duplicate units for a chemical company comprising C-E Vertical-Unit Boilers, Type VU-40 fired by C-E Spreader Stokers, continuous discharge type. These are baffleless boilers designed for a capacity of 150,000 lb steam per hr at 900 psig and 808 F. Coal is Eastern Bituminous.

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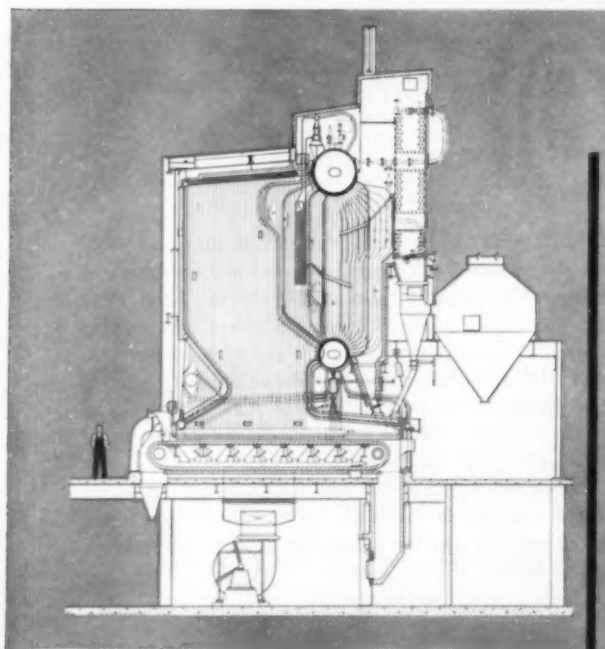
STEAM GENERATING UNITS; NUCLEAR REACTORS; PAPER MILL EQUIPMENT; PULVERIZERS;

stoker, boiler, furnace and – if desired – heat recovery equipment and/or auxiliaries, all engineered specifically for your particular requirements.

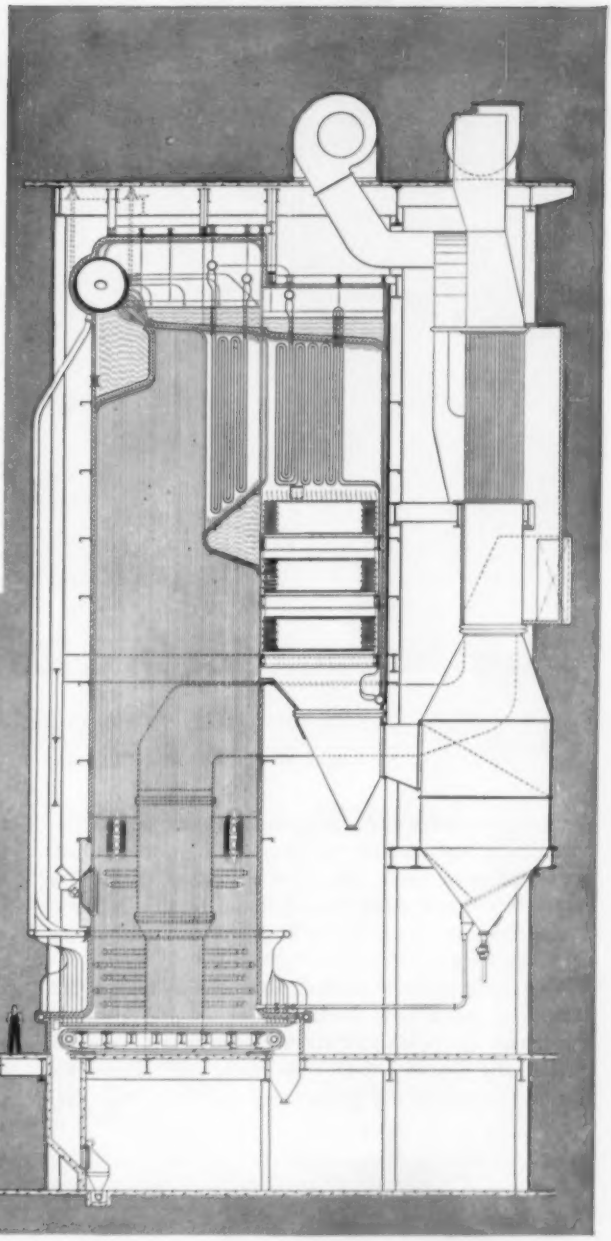
Displayed below are three – of the many – C-E stoker-fired boiler designs which, collectively, are suitable for any coal-firing conditions.

At the right is illustrated the latest – and largest – example of the C-E Bark-burning Unit, a design pioneered by Combustion and now widely used for burning bark, hogged-wood and other waste wood fuels.

So – when you are in the market for coal or other solid-fuel-burning units it will certainly be to your advantage to find out what Combustion Engineering has to offer. Our engineers will be glad to discuss your needs with you or your consultants. B-892



This C-E Unit is being installed for a soap company. It comprises a C-E Vertical-Unit Boiler, Type VU-50 fired by a C-E Traveling Grate Stoker. Coal used is Midwest Bituminous. This boiler is designed for a capacity of 100,000 lb steam per hr at 850 psig and 585 F. It is an outdoor type unit.



C-E Bark-Burning Unit for a paper company. This is a very large unit; capacity – 450,000 lb steam per hr, operating pressure – 1335 psig; total steam temperature – 958 F. It is designed to burn bark, natural gas, oil or any combination thereof. C-E Bark-Burning Boilers are in service for capacities as low as 20,000 lb of steam per hr.

ENGINEERING

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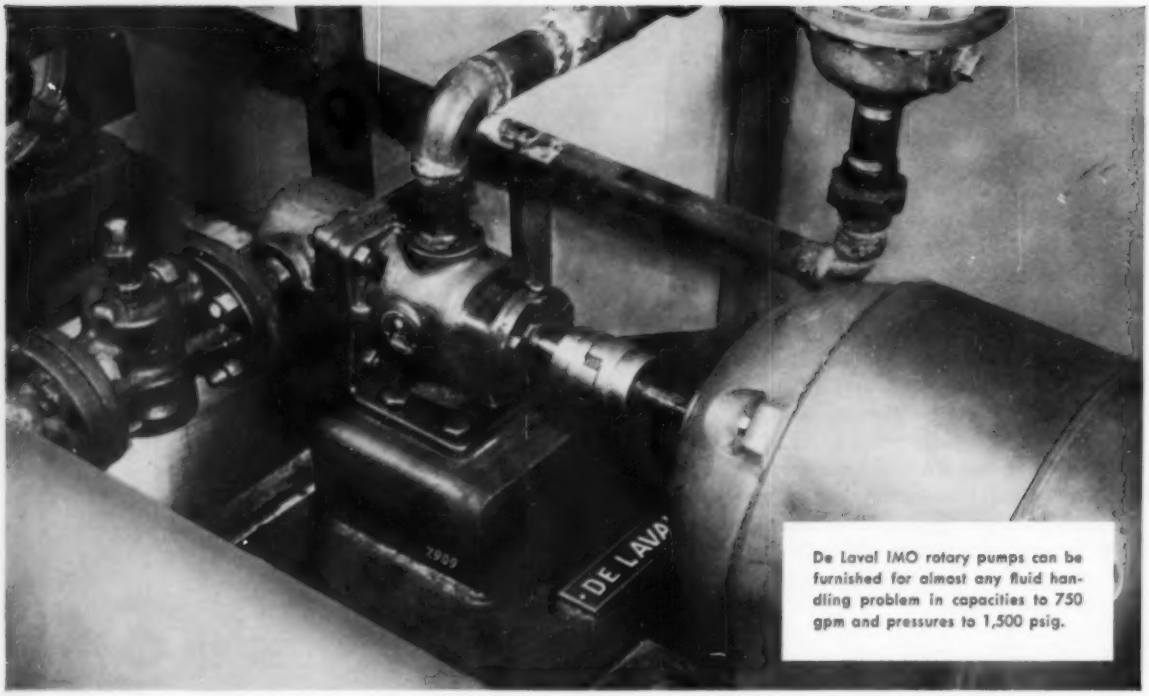
FLASH DRYING SYSTEMS; PRESSURE VESSELS; DOMESTIC WATER HEATERS; SOIL PIPE



De Laval IMO rotary pumps can be furnished for almost any fluid handling problem in capacities to 750 gpm and pressures to 1,500 psig.

What to Look for in a Rotary Screw Type Pump

By W. J. MONCON, *Assistant Chief Engineer*
De Laval Steam Turbine Company

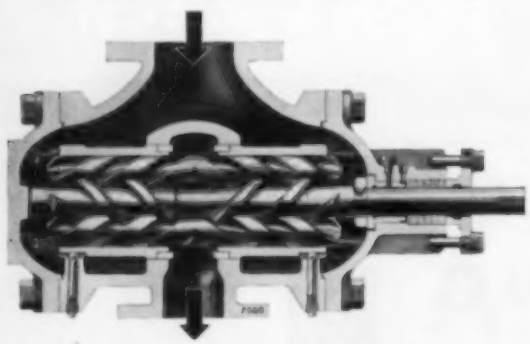
A sound knowledge of design, and how it affects performance, is the best insurance a buyer can have that he will get the pump he needs. This brief analysis of the IMO, a rotary three-screw pump manufactured by the De Laval Steam Turbine Company, will give you some of the necessary facts.

What qualities should you look for in a rotary type pump? It must, of course, meet specified capacities and pressures. But, it must also be efficient, operate quietly, stay on the job.

The axial flow of a screw type pump, and the resulting low inlet losses for any given pump speed, are important benefits that should be considered in making pump selections. The absence of timing gears and other mechanical features of construction also enable the De Laval IMO pump to operate at direct-connected motor and turbine speeds . . . to handle viscous liquids and high suction lifts.

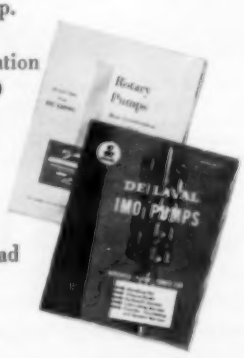
One of the most important features of the IMO pump is the hydraulic turning of the idler or sealing rotors. The central or power rotor is the pumping element; the liquid pumped turns the sealing rotors.

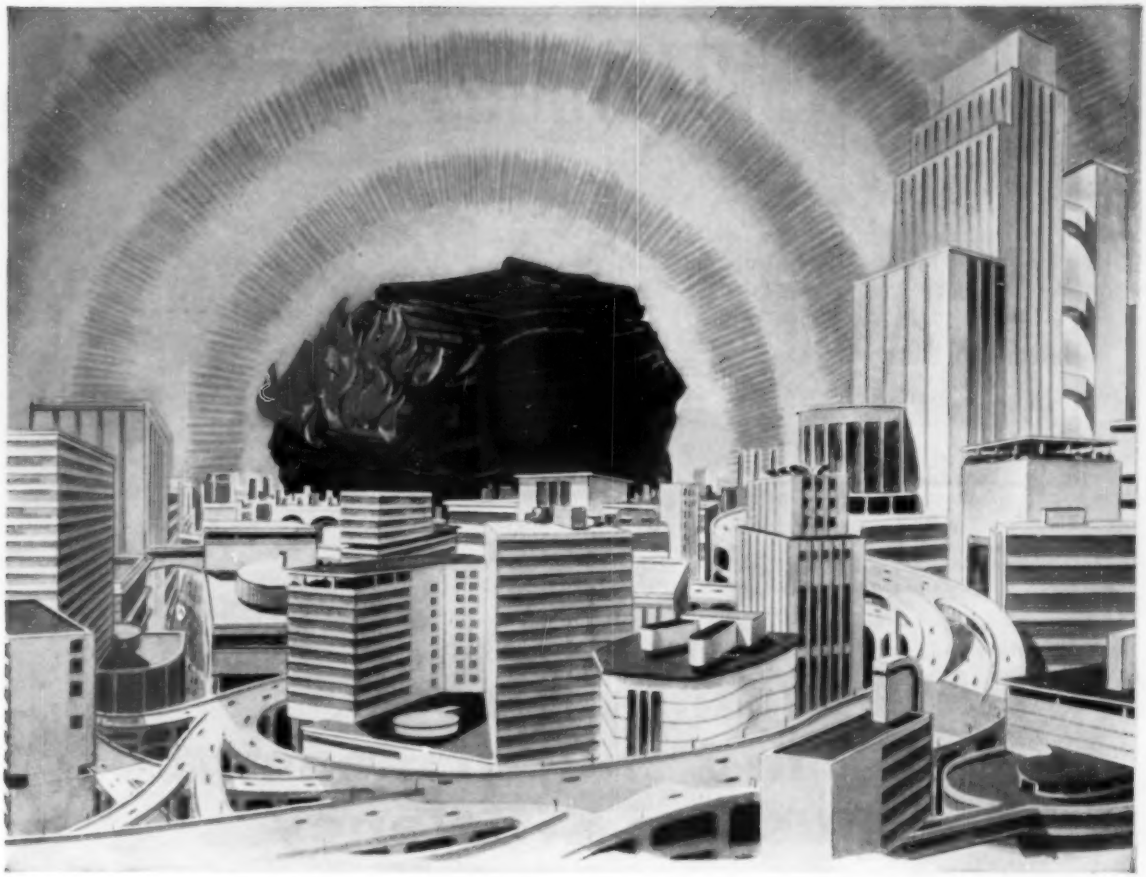
A screw type pump is well suited for applications where pulsation-free flow is desirable. The axial flow of the liquid without trapping and the unique thread form which keeps closures fluid-tight contribute to quiet operation of the IMO pump.



De Laval IMO Series A322A, a positive displacement, rotary screw type pump, can handle capacities to 750 gpm and pressures to 150 psig.

Catalog LS gives useful application and specification data on the IMO pump. An article titled, *Rotary Pumps, Basic Considerations in Their Application*, contains a description of rotary pumps in general. For these publications, write on your company letterhead to De Laval Steam Turbine Company, 886 Nottingham Way, Trenton 2, New Jersey. DL-301





The fuel that sparked our nation's growth secures her greater future

A young America—primed by a new and power-packed fuel—became a great industrial giant almost overnight. Coal had supplied the first unwavering spark which was to grow into the brightest productive flame the world has ever known.

After being served so well in the past and present, America looks again to dynamic coal for greater prosperity and security in the future. The vast Bituminous fields along the Baltimore & Ohio contain excellent coals in wide variety—available for centuries to come.

BITUMINOUS COALS FOR EVERY PURPOSE

Highly mechanized mines, equipped and ready for any demands, will help maintain long-range cost stability. And improved utilization methods will meet the increased requirements of the future by providing greater coal-burning efficiency.

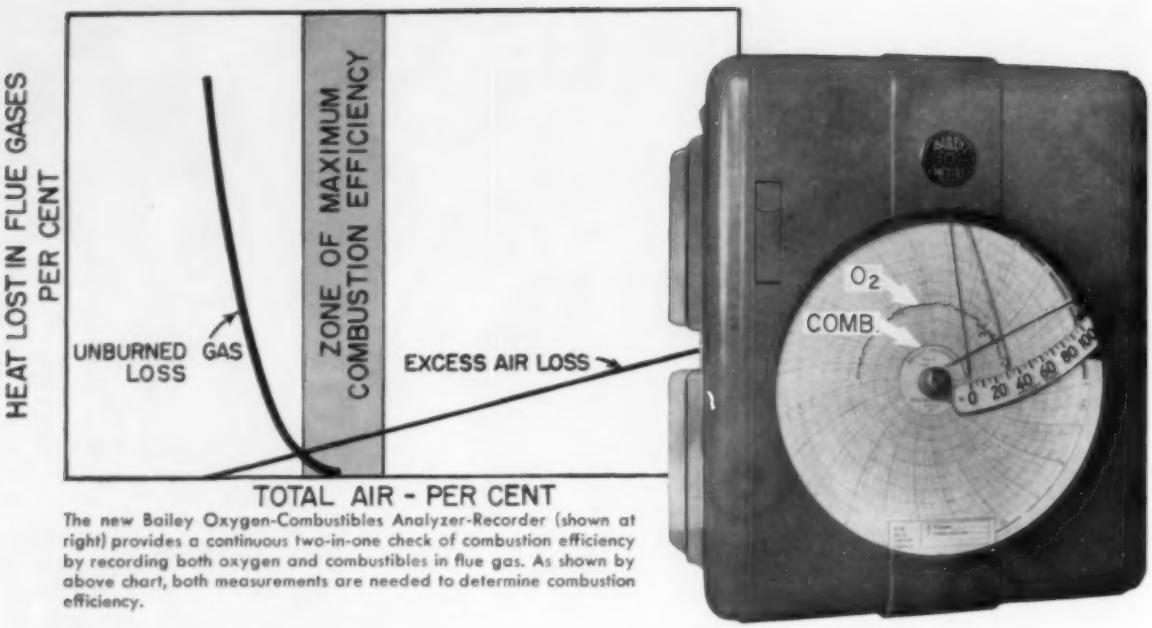
CALL ON OUR COAL TECHNICAL SERVICE

You'll receive complete information from trained B&O experts about the kind and size of Bituminous coal that fits your needs best—at a price you want to pay. Write:

COAL TRAFFIC DEPARTMENT
BALTIMORE & OHIO RAILROAD
BALTIMORE 1, MARYLAND

Baltimore & Ohio Railroad

Constantly *doing things* — better!



The new Bailey Oxygen-Combustibles Analyzer-Recorder (shown at right) provides a continuous two-in-one check of combustion efficiency by recording both oxygen and combustibles in flue gas. As shown by above chart, both measurements are needed to determine combustion efficiency.

BAILEY announces · · ·
New 2 in 1 way to measure Combustion Efficiency

The new Bailey Oxygen-Combustibles Analyzer-Recorder gives you a continuing double check on combustion economy. It's fast response measures and records:

1. Excess air—regardless of the fuel or combinations of fuels being burned.

2. The mixing efficiency of your fuel-burning equipment—by indicating the amount of combustibles in your flue gas, resulting from incomplete mixing of fuel and air.

Combustion efficiency depends upon fuel-air ratio. Too much fuel can be even more costly than too much air. And because of the interdependence of these two factors, no control that measures only one of them can give you complete protection.

Now, for the first time, you can check *both* with a *single* fast acting instrument, using the new Bailey Oxygen-Combustibles Analyzer-Recorder for industrial furnaces, kilns, heaters and boilers.

Fuel economy improves as excess air is reduced —until unburned fuel begins to show up in the flue gas. When this happens, combustion efficiency drops off sharply if there are further decreases in the air-fuel ratio. That's why combustion gases must be analyzed for *both* oxygen and combustibles to get a true indication of efficiency—and that is why Bailey coordinates both measurements on the same chart, to show when excess air may be reduced safely without danger of greater losses from unburned gases.

The Bailey Oxygen-Combustibles Analyzer is an approved combustion safeguard.

Ask your local Bailey engineer for suggestions on application. Equipment details in Product Specifications E65-1 and E12-5. P31-1

BAILEY METER COMPANY

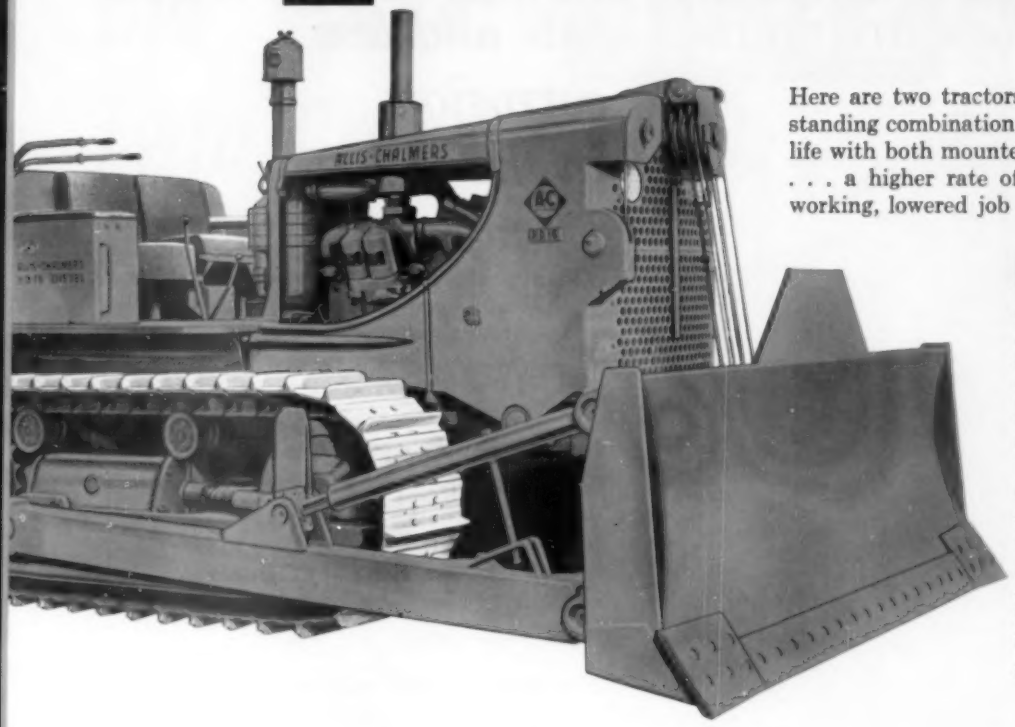
1025 IVANHOE ROAD • CLEVELAND 10, OHIO

INSTRUMENTS AND CONTROLS

For Power And Process

your choice of

TWO BIG COAL-HANDLING TRACTORS



Here are two tractors that offer you an outstanding combination of performance and long life with both mounted and drawn equipment . . . a higher rate of production, more time working, lowered job costs.

HD-16

The HD-16 — ideal for either dozing or pulling a scraper. A rugged, dependable producer with the ability to do jobs in the work range of bigger, more expensive dozers.

Choose from two outstanding drives:

Torque Converter Drive, with 150 net engine hp and 31,600 lb weight — or Standard Transmission Drive, with 131 belt hp, and 31,500 lb weight.

NEW STANDARDS OF PERFORMANCE

Allis-Chalmers tractors bring you more power for bigger jobs . . . make more effective use of horsepower, with brand new Allis-Chalmers diesel engines and your choice of two new drives — the job-proved torque converter in the HD-16 and HD-21 or the easy-shift standard transmission in the HD-16. Either way, you get a new high in tractor-operator efficiency . . . a new high in work done under even the toughest conditions.

HD-21

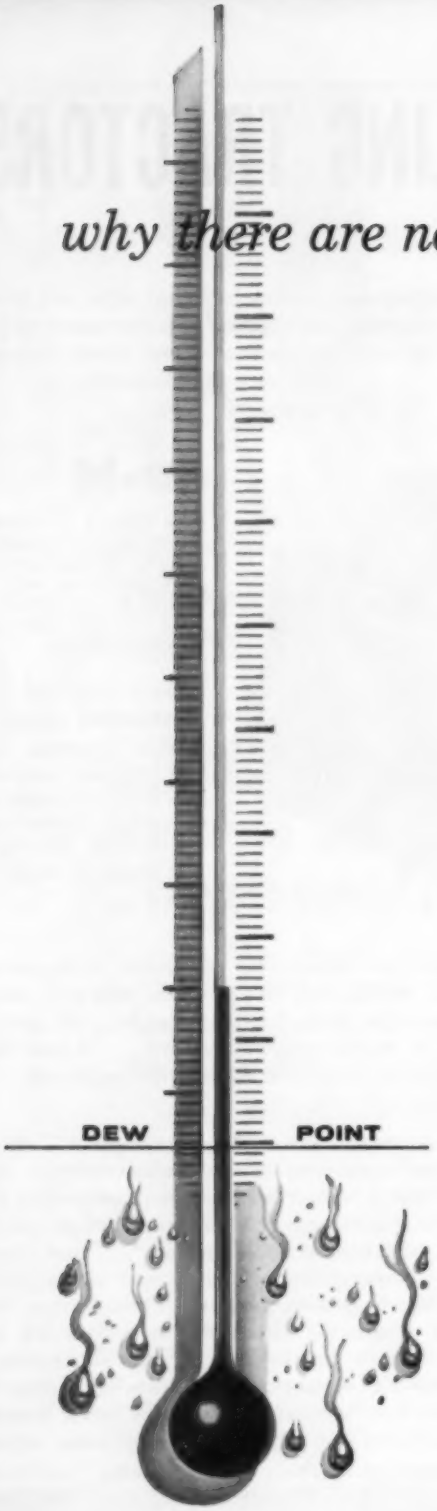
Torque Converter Drive
204 net engine hp
44,000 lb

NEW STANDARDS OF DEPENDABILITY

Allis-Chalmers advanced basic design in both these tractors brings you such important features as all-steel, box-A main frame and one-piece steering clutch and final drive case . . . straddle-mounted final-drive gears with tapered roller bearings . . . unit construction . . . simplified lubrication and service designed with better maintenance in mind. What's more, they're newly engineered throughout to provide big safety factors in all components . . . plus outstanding new features like the new Allis-Chalmers heavy-duty diesel engine, new "wrap-around" radiator guard, husky new transmission, new long-life track, and many others.

Learn more about these and other coal-handling units from your Allis-Chalmers Construction Machinery Dealer.

ALLIS-CHALMERS



why there are no cold spots and less corrosion in the Ljungstrom® Air Preheater

In the Ljungstrom, the heat-transfer surface rotates alternately through the gas and the air streams . . . keeping heating elements consistently hotter than other types in equivalent service. That's why there are no cold spots . . . and less corrosion in the Ljungstrom.

Even though corrosive action is slow, some does take place at the cold end of the Ljungstrom. This presents no problem, since the cold end is sectionalized to permit easy reversal and almost double life. Reversing or replacing the cold end does not disturb the rest of the elements and takes just a few hours.

Get all the details on the Ljungstrom Air Preheater. Send for the new, free, 38-page reference manual, "Ljungstrom Air Preheaters."

Advantages of the Ljungstrom Air Preheats

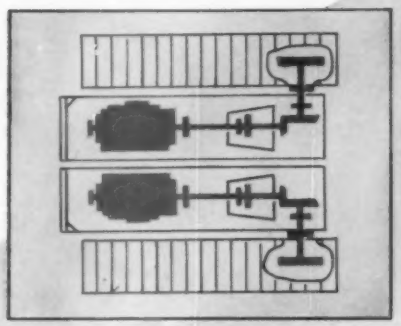
- Size for size, recovers more heat than any other type.
- Reduces fuel consumption. Permits use of lower-grade fuels. Increases boiler output and reliability.
- Eliminates cold spots . . . keeps corrosion to a minimum.
- Easier, faster to clean and maintain.
- Requires far less supporting steel and is quickly erected.

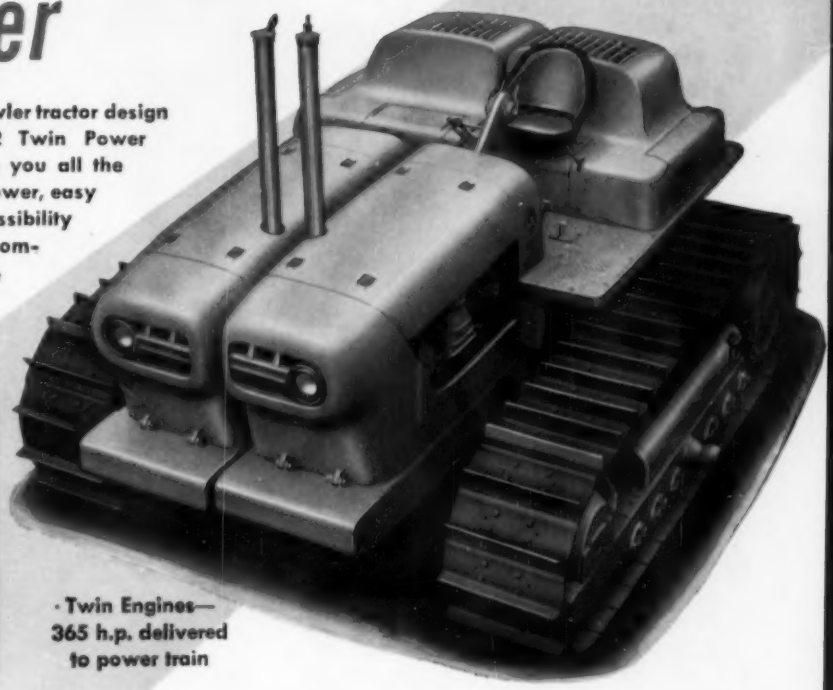
The Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.

Biggest Tractor News in Years...

the "Euc" TC-12 Twin Crawler

Here's a completely new concept of crawler tractor design and performance . . . the new TC-12 Twin Power Euclid. It's designed and built to give you all the features you want in a tractor—more power, easy operation, greater workability and accessibility for servicing . . . and all power train components are matched, with years of application in earth moving equipment.





· Twin Engines—365 h.p. delivered to power train

SPECIFICATIONS

total h.p.—388 h.p. at rated speed	
available for tractive effort—365 h.p.	
speeds—3 speed ranges forward and reverse to 8.3 mph	
drawbar pull (bare tractor)—forward and reverse	54,000 lbs. low range 53,500 lbs. intermediate 53,000 lbs. high range
track width (standard shoe)	26"
track gauge	110"
overall width	11' 4"
overall length	16' 2"
height (excluding stacks)	7' 11"
drawbar height	23"
ground clearance	20"
operating weight (bare)	approx. 58,000 lbs.

Powered by two diesels with separate Torqmatic Drives for each track, the TC-12 has 365 h.p. available for tractive effort—a smooth steady flow of power to meet any job requirement. There's no master clutch and no manual gear shifting . . . the operator simply moves a lever to select one of three speed ranges—forward and reverse—for travel speeds up to 8.3 m.p.h. Maximum drawbar pull is equal to, or greater than, the weight of the tractor and any attachments.

Each half of the tractor is separate and free to oscillate on a single transverse shaft. This gives the TC-12 maximum stability and traction on rough ground. The tractor can be easily separated into two halves for shipment when necessary.

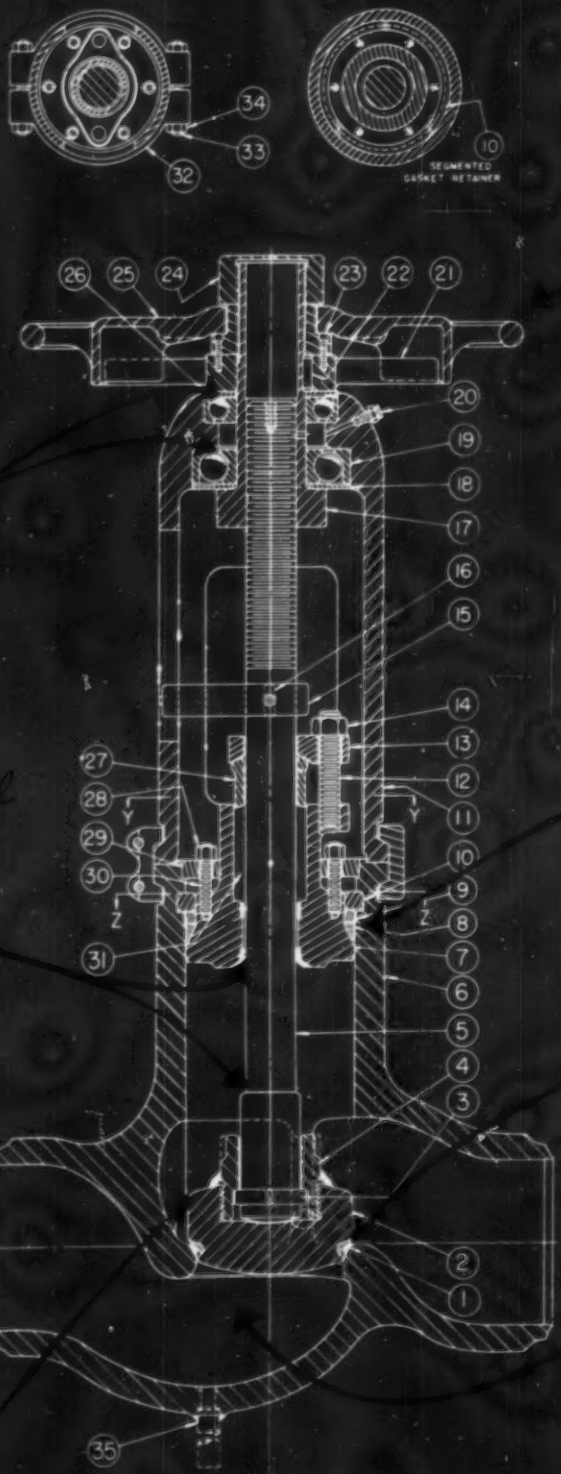
Never before so much workability!

EUCLID DIVISION GENERAL MOTORS CORPORATION, Cleveland 17, Ohio

Euclid Equipment

FOR MOVING EARTH, ROCK, COAL AND ORE

D.C.H.—
Note comments.
These features
are worth money
to us! C.R.B.



ROCKWELL BUILT *Edward Valves*

LIST OF MATERIALS

QUANTITIES ARE FOR ONE VALVE

WHERE A.S.T.M. SPECIFICATIONS ARE INDICATED, THE LATEST REVISION APPLIES

REF. NO.	NAME OF PIECE	NO. REQ'D	MATERIAL	SPECIFICATIONS	EDWARD M'S NO.
1	SEAT	1	INTEGRAL WITH BODY	STELLITED	481
2	DISK	1	FORGED ALLOY STEEL WITH STELLITED SEATING FACE	A.S.T.M. A182, GRADE F11 WITH C.012% MAX. CR 1¼% MO ½%	227 481
3	STEM COLLAR	1	EVALLOY	A.S.T.M. A182, GRADE F6	212
4	DISK NUT	1	EVALLOY	A.S.T.M. A182, GRADE F6	212
5	STEM	1	EVALLOY	A.S.T.M. A182, GRADE F6	212
6	BODY		CAST STEEL C-0.30% MAX	A.S.T.M. A216, GRADE WCB	102
			CAST STEEL C-0.20% MAX	A.S.T.M. A217, GRADE WC6	226
			CAST STEEL C-0.18% MAX	A.S.T.M. A217, GRADE WC9	242
7	BONNET	1	CAST STEEL C-0.25% MAX	A.S.T.M. A217, GRADE WCI	209
8	PRESSURE SEAL GASKET	1	ARMCO IRON, 90 BHN MAX	MALLEABLE PLATED	506
9	SPACER RING	1	STEEL		
10	GASKET RETAINER	1	EVALLOY	A.S.T.M. A182, GRADE F6	212
11	YOKE	1	CAST STEEL C-0.30% MAX	A.S.T.M. A216, GRADE WCB	102
12	GLAND STUDS	2	ALLOY STEEL	A.S.T.M. A193, GRADE B7	208
13	GLAND FLANGE	1	STEEL PLATE	A.S.T.M. A212, GRADE B	115
14	GLAND BOLT NUTS	2	STEEL	A.S.T.M. A194, CLASS 1 OR 2	124
15	STEM GUIDE COLLAR	1	STEEL PLATE	A.S.T.M. A212, GRADE B	115
16	STEM GUIDE KEY	1	STEEL	S.A.E. 1020	
17	YOKE BUSHING	1	CAST BRONZE	A.S.T.M. B-148 GRADE 9B-HT	432
18	BEARING WASHER	1	STEEL-EVALIZED	A.S.T.M. A212, GRADE B	115
19	ANGULAR CONTACT BALL BEARINGS			S.A.E. STANDARD	
20	LUBRITE FITTING	1	BUTTON-HEAD INDUSTRIAL TYPE		
21	CROSSARM	1	CAST STEEL C-0.30% MAX	A.S.T.M. A216, GRADE WCB	102
22	CROSSARM KEY	1	STEEL	S.A.E. 1020	
23	HANDWHEEL BUSHING	1	BRASS	A.S.T.M. B62	412
24	HANDWHEEL LOCKNUT	1	STEEL PLATE	A.S.T.M. A212, GRADE B	115
25	IMPACTOR HANDWHEEL	1	CAST IRON	A.S.T.M. A126, CLASS A	30
26	BEARING WASHER	1	STEEL-EVALIZED	A.S.T.M. A212, GRADE B	115
27	GLAND	1	STEEL	A.S.T.M. A105, GRADE 1	111
28	BONNET RETAINER NUTS	6	STEEL	A.S.T.M. A194, CLASS 2H	127
29	BONNET RETAINER RING	1	STEEL PLATE	A.S.T.M. A212, GRADE B	115
30	BONNET RETAINER STUDS	6	ALLOY STEEL	A.S.T.M. A193, GRADE B7	208
31	PACKING RINGS		HIGH TEMPERATURE PACKING		
32	STEM LOCK RING	1	CAST STEEL C-0.30% MAX	A.S.T.M. A216, GRADE WCB	102
33	YOKE RING STUDS	4	ALLOY STEEL	A.S.T.M. A193, GRADE B7	208
34	YOKE RING STUD NUTS	8	STEEL	A.S.T.M. A194, CLASS 2H	127
35	DRAIN NIPPLE	1	CHROME MOLYBDENUM	SCHEDULE 160 PIPE	229

EDWARD VALVES, INC.
SUBSIDIARY OF ROCKWELL MANUFACTURING CO.
EAST CHICAGO, INDIANA

EDWARD GLOBE STOP VALVE
PRESSURE SEAL BONNET — WELDING ENDS
GENERAL ASSEMBLY

DRAWN		DRAWING NO.
CHK'D		AE-3297-5
APP'D	DATE:	

Edward builds Globe and Angle Stop, Non-Return, Stop-Check, Check, Gate, Blow-Off, Mudline, Relief, Hydraulic, Instrument, Gage, and Special Valves and Strainers.

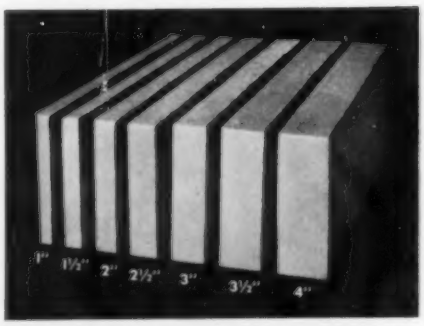
Specify J-M Superex, industry's favorite block insulation

Made from diatomaceous silica and asbestos for all temperatures to 1900F

YOU'LL ENJOY *greater insulation savings* with Superex®. Its unique combination of low conductivity and outstanding resistance to high temperatures provides greater operating efficiency and longer maintenance-free service. That's why Superex is the leading block insulation for furnace work.

Light and easy to work. Superex withstands temperatures to 1900F indefinitely with negligible loss of efficiency and is so strong that it compresses only ⅛ inch under 6 tons' pressure per square foot. Its light weight, excellent working properties and availability in large blocks mean quick, easy, low-cost installation.

For high temperature equipment. Since its introduction in 1927, Superex has received enthusiastic acceptance. Today it economically insulates 90% of the country's hot blast stoves. Other high temperature equipment where Superex has proved its superior performance include most types of industrial and metallurgical furnaces and ovens, stationary and marine boilers, regenerators, kilns, roasters, high-temperature mains, flues and stacks.



Saves waste—Superex comes in 7 standard thicknesses from 1" to 4". Other sizes available on order.

For further information on Superex, write to Johns-Manville, Box 60, New York 16, N. Y. In Canada, Port Credit, Ont.

Johns-Manville *first in* **INSULATION**

MATERIALS · ENGINEERING · APPLICATION

"Wet Coal Flows Much Better Over Stainless-Clad Steel..."

These three stainless-clad steel coal chutes at Potomac Edison's Smith Station have provided trouble-free service for 2, 2½ and 3½ years respectively.

The R. Paul Smith Station of the Potomac Edison Co., at Williamsport, Md., had experienced considerable hangup trouble due to wet coal. Now they find that "wet coal flows much better over stainless-clad steel than it did over carbon steel. This is a great factor in our using it." Stainless-clad equipment installed to date includes three coal chutes and one 36' coal pipe. These four units have averaged 3 years of service with practically no stoppage of coal flow. Clad steel's satisfactory performance has resulted in Smith Station's planning to replace carbon steel equipment as it wears out with stainless-clad steel.

Consistent economy is the major reason why clad is repeatedly chosen for replacement and original installation service. This economy results directly from clad steel's built-in qualities—a layer of stainless steel integrally and permanently bonded to strong, low-cost carbon steel backing plate. This combination provides lower initial cost than solid high-alloy plate, yet provides the same long-term, maintenance-free protection. Clad has repeatedly demonstrated its ability to provide as much as 10 years' service without any measurable loss of gage. With hard use clad steel develops smooth, mirror-like finish that means free coal flow.

For detailed information on stainless-clad steel's exceptional performance in coal handling service, write for Bulletin 740. Lukens Technical Service Department is available to work with your builders and engineers to put clad to work for you. In addition we will supply the names of qualified equipment builders who are experienced with your problems. Write to the Manager, Marketing Service, 684 Lukens Building, Lukens Steel Company, Coatesville, Pennsylvania.

LUKENS

STAINLESS-CLAD STEELS

FOR INTERIOR COAL HANDLING EQUIPMENT

LUKENS STEEL COMPANY, COATESVILLE, PENNSYLVANIA

PRODUCER OF THE WIDEST RANGE OF TYPES AND SIZES OF CLAD STEELS AVAILABLE ANYWHERE

NOW... greater piping loads, longer travels, with less headroom

The Grinnell Model R Constant-Support Pipe Hanger is available now in an *extended range* of sizes to provide completely overlapping coverage of loads from 47 lbs. to 32,267 lbs., and with travels up to 12 inches. New design modifications permit these hangers to be installed with a minimum of headroom, ranging from 29 inches (rod take-out) for the largest size — down to 10¾ inches for the smallest size.

The Model R provides constant support which is mathematically perfect for all positions of travel. This constancy of support is maintained throughout the full range of field adjustability. Needle bearings minimize friction.

Grinnell Constant-Supports are individually calibrated to support the exact load specified. All Model R Constant-Supports have a full 70 percentage points of field adjustability built into them. No less than 10% of this adjustability is allowed either side of calibration for plus or minus change in load. Field re-adjustments are easily made by turning a single load adjustment bolt.

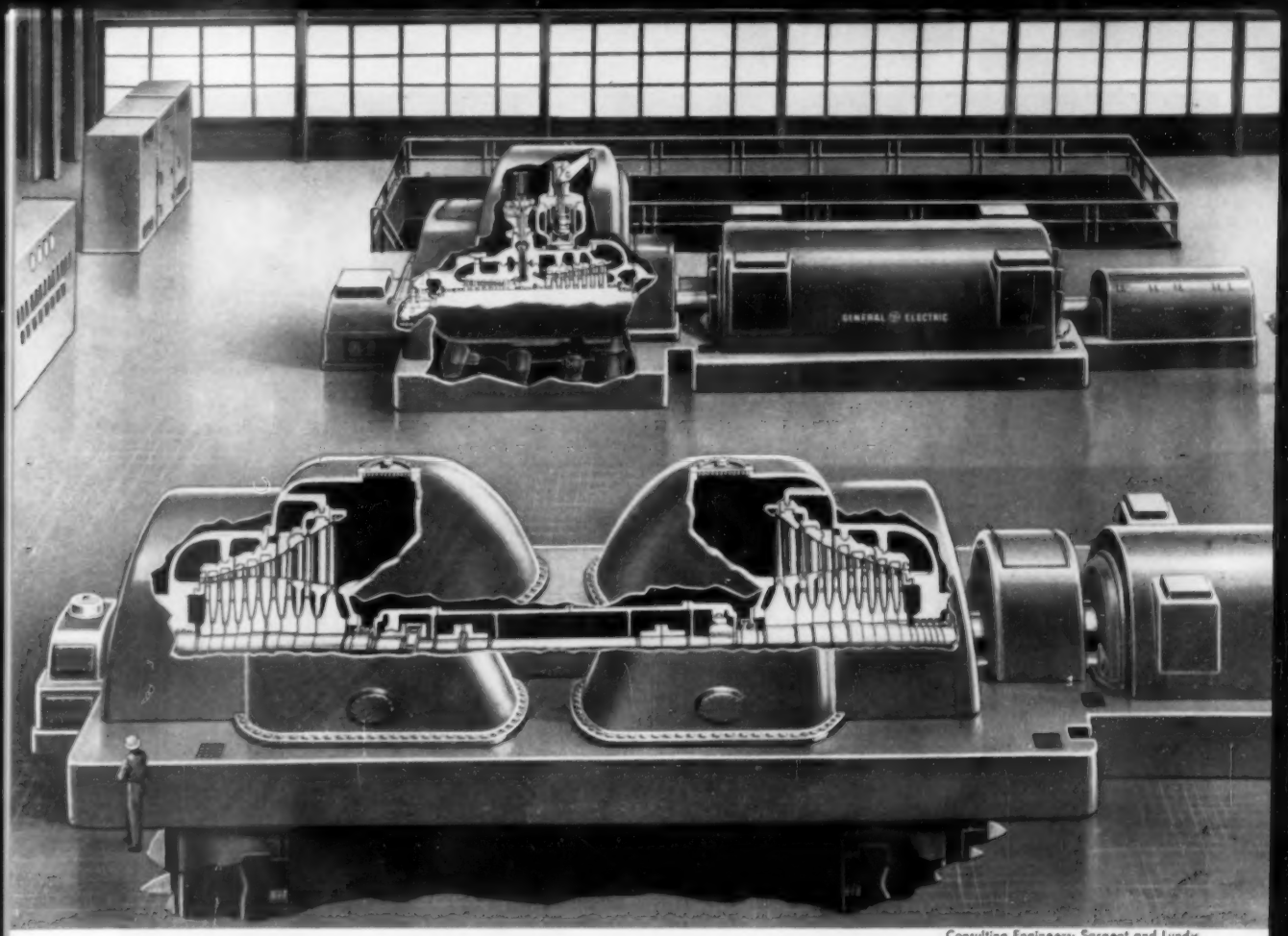
Grinnell designs, manufactures, and distributes a complete line of pipe hangers and supports for every piping requirement. Grinnell maintains an experienced staff of engineers in the field — ready to assist you on the job with any piping problem.

GRINNELL

AMERICA'S #1 SUPPLIER OF PIPE HANGERS AND SUPPORTS

Grinnell Company, Inc., Providence, Rhode Island • Coast-to-Coast Network of Branch Warehouses and Distributors

pipe and tube fittings • welding fittings • engineered pipe hangers and supports • Thermolier unit heaters • valves
Grinnell-Saunders diaphragm valves • pipe • prefabricated piping • plumbing and heating specialties • water works supplies
industrial supplies • Grinnell automatic sprinkler fire protection systems • Amco air conditioning systems



Consulting Engineers: Sargent and Lundy

GENERAL ELECTRIC TURBINE-GENERATOR IN WILL COUNTY STATION, PUBLIC SERVICE CO. DIVISION, COMMONWEALTH EDISON CO.

New Developments in G-E Cross-compound Turbines Offer Greater Operating Economy

Keeping pace with the electrical industry's need for higher ratings and efficiencies with resultant fuel savings are General Electric developments in cross-compound turbines.

An application of this design is Unit No. 2 in the Will County Station of the Public Service Company Division, Commonwealth Edison Company, shown above. This installation typifies the vigorous efforts being made by progressive electric utilities to expand and to improve the efficiency of their generating systems in order to provide adequate, low-cost electricity for rising loads.

Separation of high- and low-pressure sections allows greater efficiency in each. The 1800-rpm speed of the low-pressure section (foreground) permits use of longer, last-stage buckets which provide more efficiency at low exhaust pressures.

The 3600-rpm, high-pressure section's opposed-flow design avoids severe temperature gradients with their thermal distortion by concentrating high steam temperatures in a small area of the casing. This feature and use of special high-pressure, high-temperature parts result in outstanding efficiency. Fuel savings on a typical 250,000-kw cross-compound unit can be as much as 50,000,000 pounds of coal per year.

Because there are two sections, each is comparatively short—a feature helpful in making more compact station arrangements. Some cross-compound units can be fitted into extensions of existing stations that cannot accommodate other designs of equal rating.

The best General Electric turbine today burns 29 percent less fuel per kilowatt-hour than the most efficient unit of 20 years ago. The opportunity for continued improvement offers a challenge that is being met by the ingenuity and creativity of many G-E people in research, engineering, and manufacturing. Large Steam Turbine-Generator Department, General Electric Company, Schenectady 5, N. Y. 254-36A

Progress Is Our Most Important Product

GENERAL ELECTRIC

8 "BUFFALO" INDUCED DRAFT FANS —2,800,000 lbs/hr of POWER-PRODUCING STEAM

The eight "Buffalo" Induced Draft Fans above serve the four reheat cycle steam generators of the 400,000-kw Wabash River Station of the Public Service Company of Indiana, Inc., above, right. It takes a lot of air to produce power—and the source of air must be as reliable as the fuel. This is why "Buffalo" is the

"Buffalo"

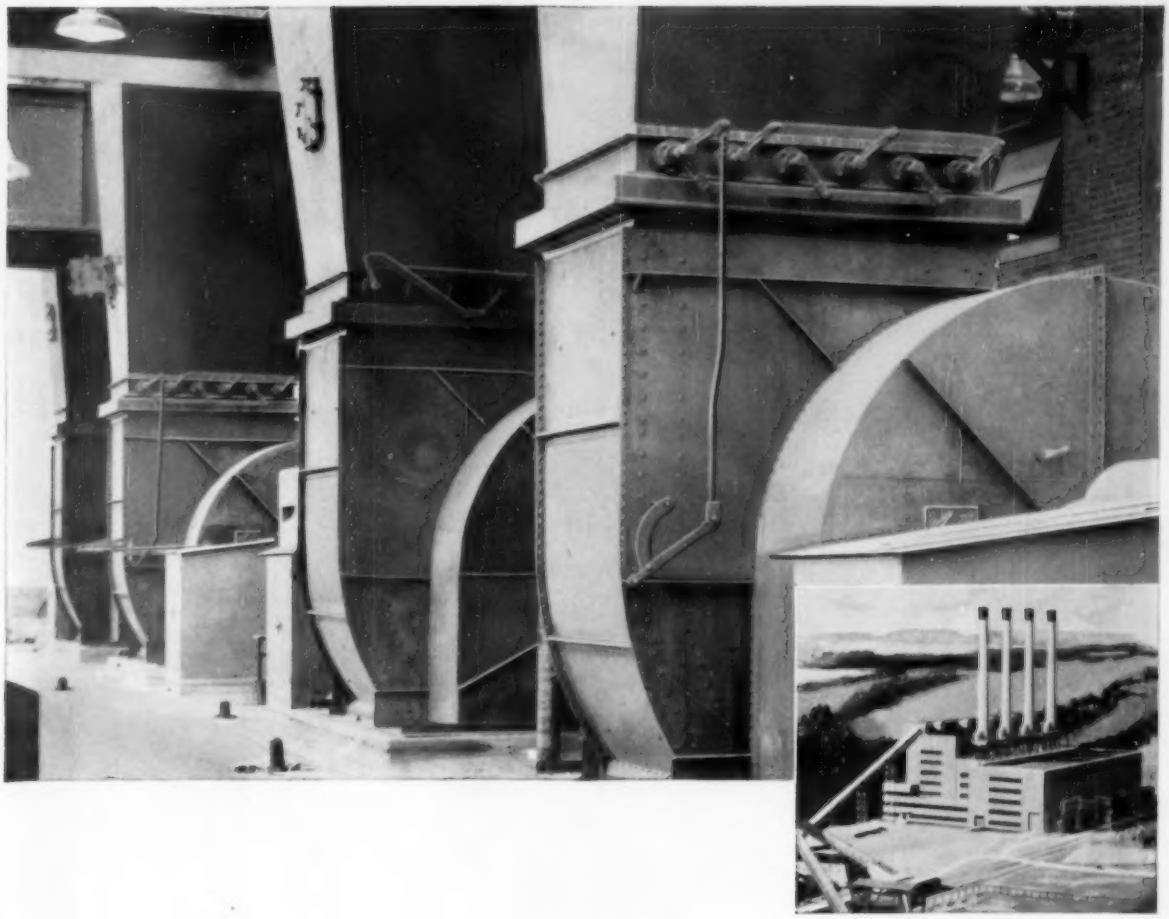
BUFFALO

170 MORTIMER ST.

PUBLISHERS OF "FAN

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT



choice for the punishing induced draft job

in so many utility stations as well as in industrial power plants. Write for Bulletin 3750 and see why "Buffalo" Forced Draft, Induced Draft, Gas Recirculating and Primary Air Fans give the dependable air delivery your boilers need for top output!

FORGE COMPANY

BUFFALO, NEW YORK

ENGINEERING" HANDBOOK

Sales Representatives in all Principal Cities

EXHAUSTING FORCED DRAFT COOLING HEATING PRESSURE BLOWING

Inside story:

Valves may look alike on the surface. Their performance is another story. And the inside story of Powell Valves is that *every* Powell Valve has *Performance Verified.*

X-ray and gamma ray inspection—examining the very structure of the metal itself—are two of the many ways that Powell can make absolutely certain that Powell Valves will give *dependable* flow control.

Every part of every valve must pass rigid inspection. As a final step in manufacture, every Powell Valve is subjected to *an actual line test.* Because of Powell's pains-taking quality control, valve repair is cut to the minimum and plant shut down through valve failure is substantially reduced. Records from refineries, power and industrial plants the world over prove it.

Consult your Powell Valve distributor. If none is near you, we'll be pleased to tell you about our COMPLETE *quality line* which has PERFORMANCE VERIFIED.

The Wm. Powell Company, Cincinnati 22, Ohio . . . 110th YEAR

PERFORMANCE PV VERIFIED

FIG. 19003 WE—900-Pound Steel Pressure Seal Gate Valve.

FIG. 11365 WE—Steel Pressure Seal Horizontal Lift Check Valve for 1500 Pounds W.S.P.

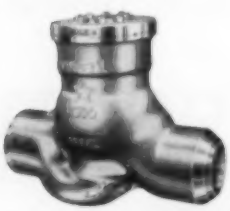


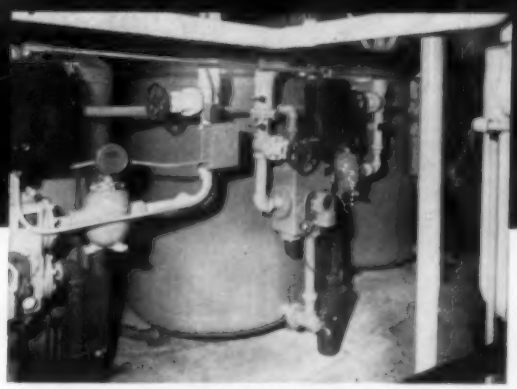
FIG. 3031 WE—Steel Globe Valve for 300 Pounds W.S.P.

POWELL VALVES

BRONZE, IRON, STEEL AND CORROSION RESISTANT VALVES.

problems in water conditioning...

SIMPLIFIED CONTROL



COCHRANE ZEOLITE SOFTENER DELIVERS WATER of zero hardness by the soap test. All commonly known zeolites—greensand, synthetic gel, sulfonated coal and the various styrene medium capacity resins are available for most practical individual application. Units can be adapted for automatic operation. Three 6' x 6' fully automatic Cochrane Zeolite Softeners above provide a capacity of 288,000 lbs. per hr.

Cochrane

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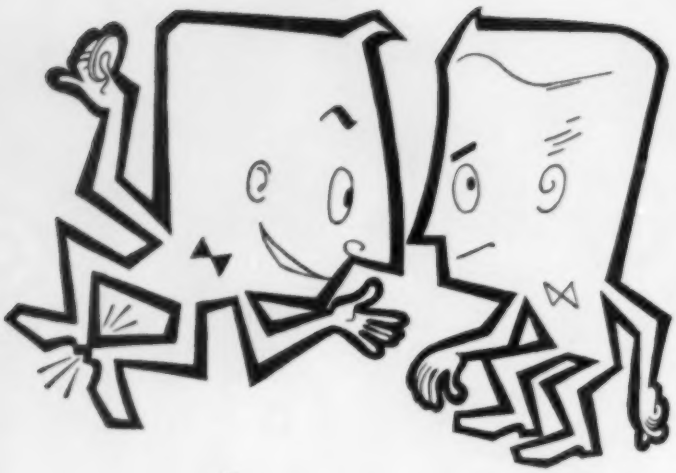
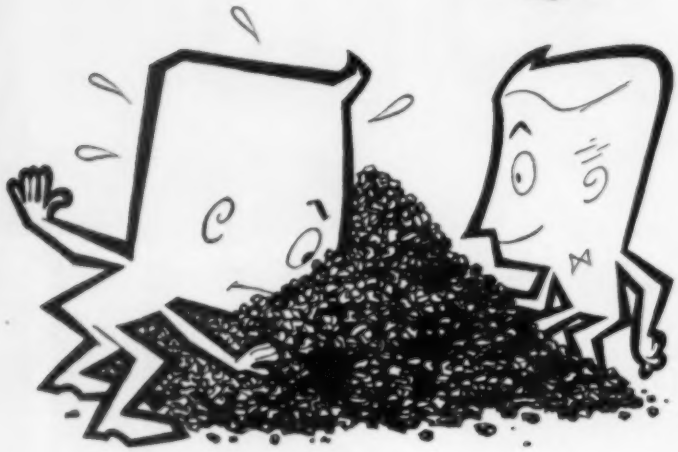


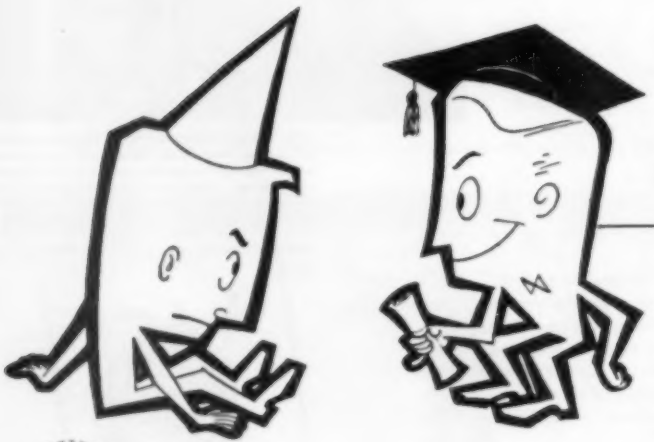
Look! I can buy coal for much less a ton than you're paying.

I used to buy that coal too, but it costs more per million BTU's with a whole lot more in hidden costs.



What do you mean by "hidden costs"?

That coal you're talking about is high in ash. So we were buying ashes at the coal price, paying freight on them from the mine, then paying to have them hauled away. Your "cheaper" coal clinkers; it smokes; it fouls the tubes. That means higher labor costs and higher maintenance. Now I pay more per ton and save thousands of dollars a year.



Coals produced on the C&O are tops in quality.

A C&O combustion engineer showed me why this grade of coal would work best in our type of installation and our experience has shown he was right. You'd better get some expert advice. It can save you money, too.

P.S.

There's a lot more to buying coal than the cost per ton. Why not contact coal producers on the C&O to solve your particular fuel requirements, or write to: R. C. Riedinger, General Coal Traffic Manager, Chesapeake and Ohio Railway Company, Terminal Tower, Cleveland 1, Ohio.

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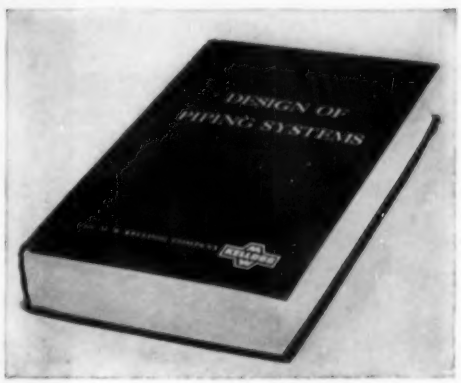

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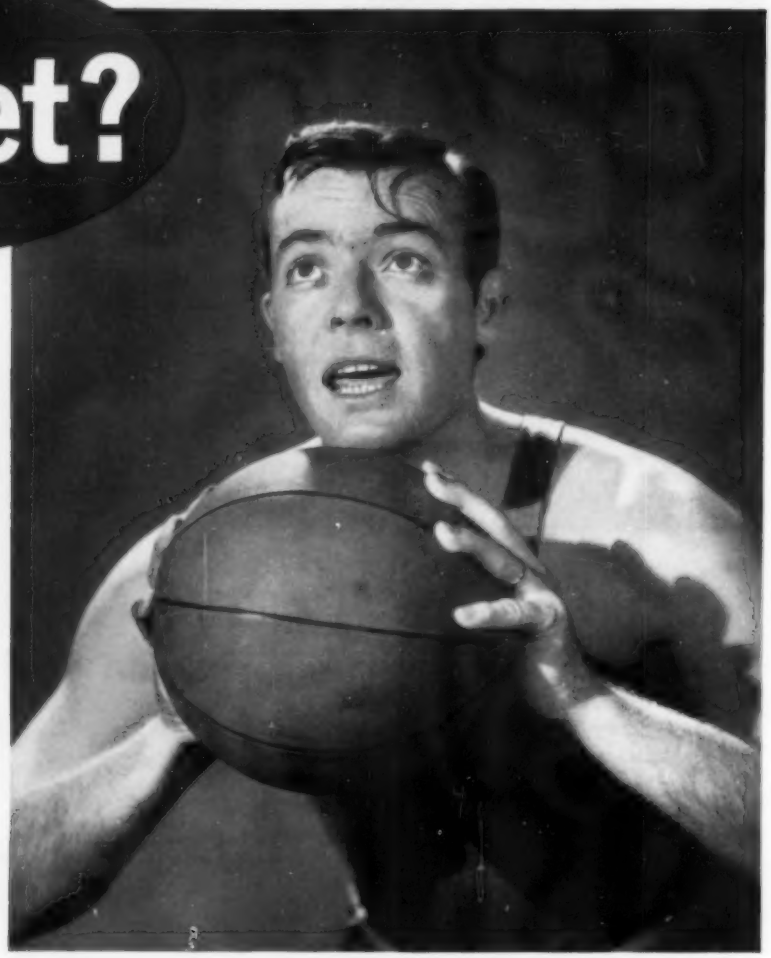

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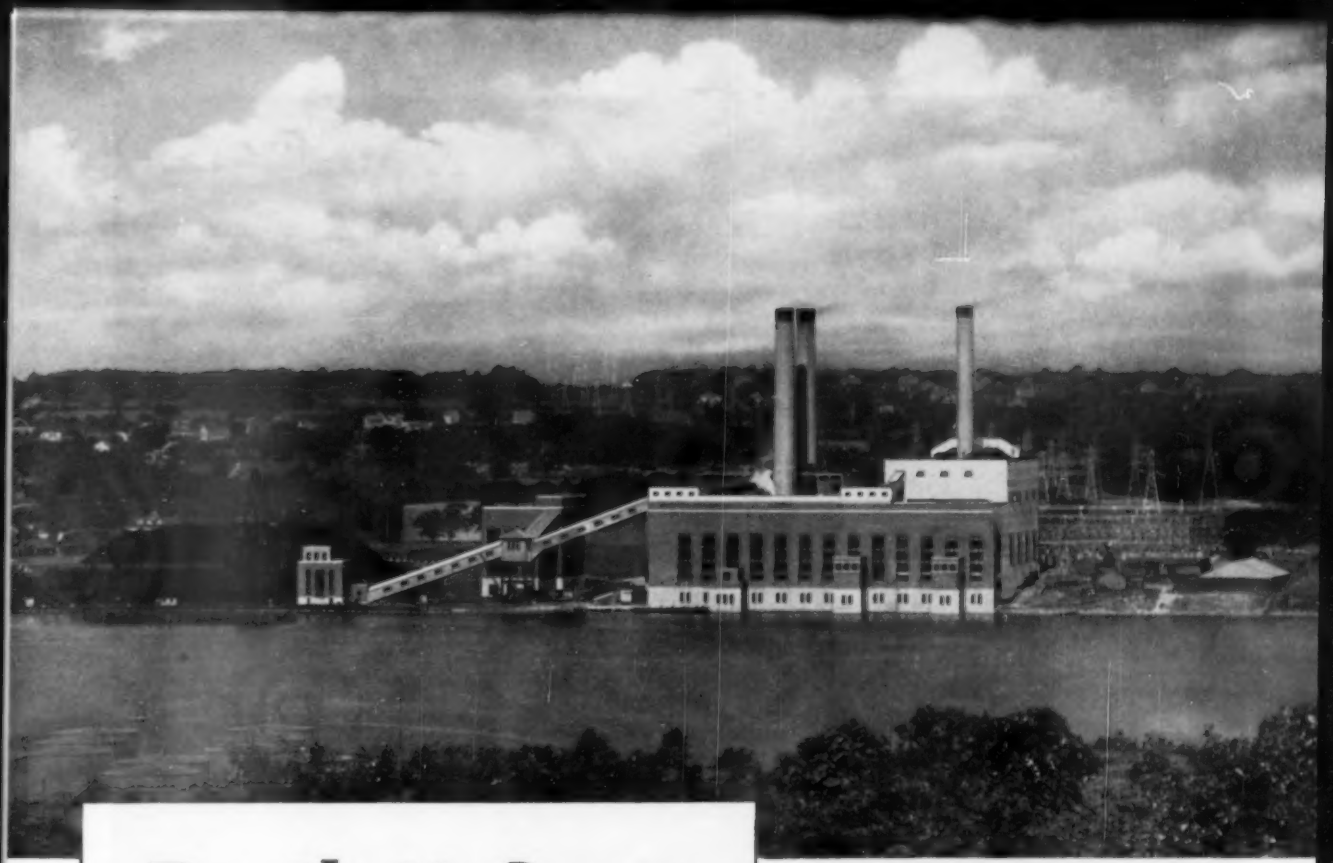
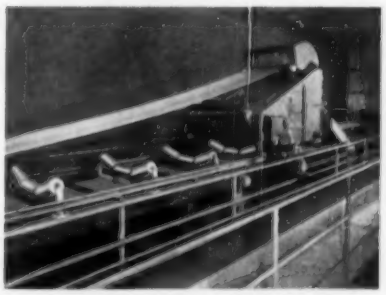


General View of Somerset Station
Montaup Electric Company
Stone and Webster Engineering Corp.
Consulting Engineers

Bartlett-Snow coal handling at Montaup

● The illustration above shows the Montaup Electric Company's Somerset Station after completion of a 60,000 K.W. extension that increased the total capacity of the plant to 210,000 K.W. The new coal handling equipment required — built and installed by Bartlett-Snow to Stone and Webster specifications — includes conveyors, weightometer and tripper. It connects into the old system at the south end of the plant, and is carried through a gallery built on the roof to discharge coal into the new bunker at the north end of the plant. For new plant projects, modernization programs, and additions and extensions to existing facilities, call the Bartlett-Snow coal handling engineers.



Bartlett-Snow Belt Conveyor Tripper
Over New Bunker

View of New Belt Conveyor Gallery
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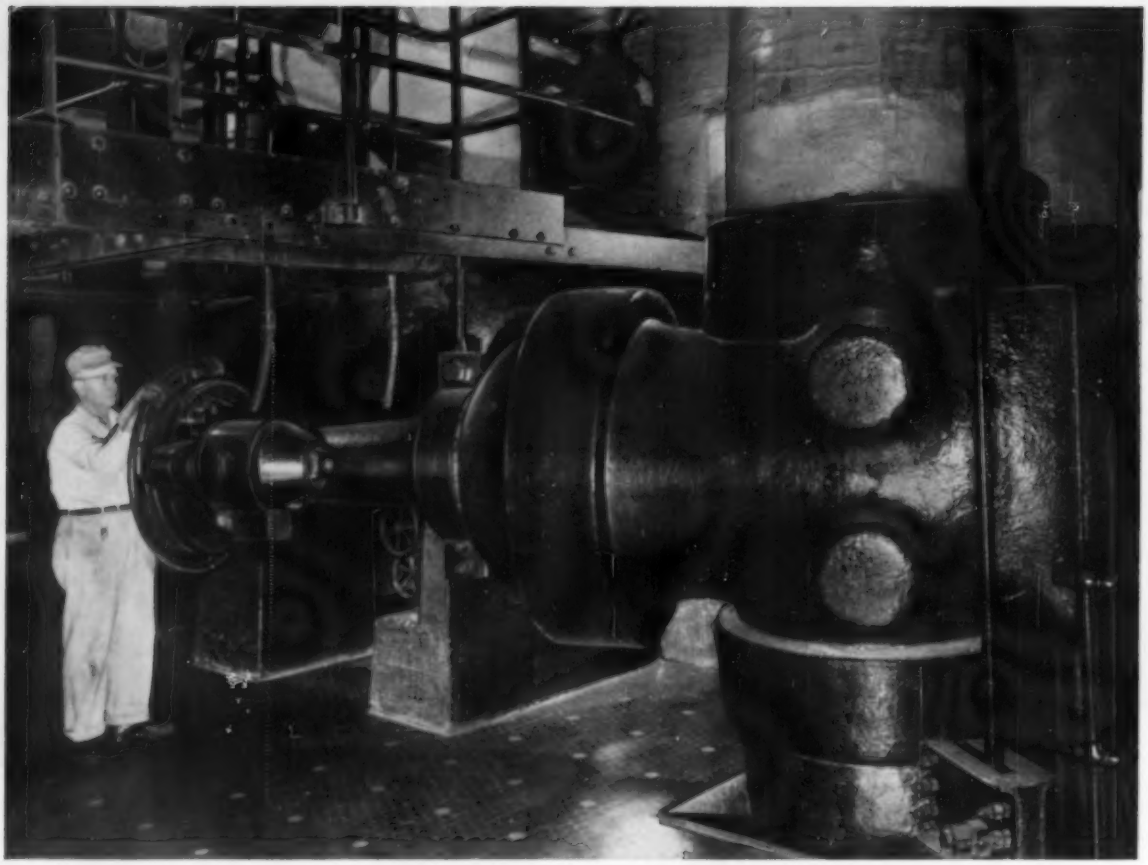

Dividends from this Crane valve over 30 years... 6¾ billion kilowatt-hours

Over thirty years ago, this 30-inch Crane steel gate valve was put in service at Commonwealth Edison's Crawford Station in Chicago.

As of May, 1955, unit No. 1 on which this motor-operated valve is installed, had been in operation more than 150,000 hours. Total power output generated with this valve in service was approximately 6,750,000,000 kilowatt-hours.

The valve is on reheat steam service with working conditions of 100 psi. at 700 degrees F. Never out of the line, and given but routine maintenance attention since installed in 1925, the valve's performance remains completely satisfactory.

Seating action is positive and tight; bonnet-joint and stem seal are tight; operation is smooth.

There is nothing special about this rising stem, cast carbon steel valve—nothing but its dependable Crane quality. Development of steel valve castings was pioneered by Crane; long life and low maintenance are deeply rooted characteristics of Crane valves.

In steel valves, as in other materials, the Crane line is most complete: gates, globes, angles, checks and stop-checks—bolted, Pressure-Seal, and Lip-Seal bonnet designs—screwed, flanged, or welding ends—sizes up to 24 in.—pressure classes up to 2500 psi.

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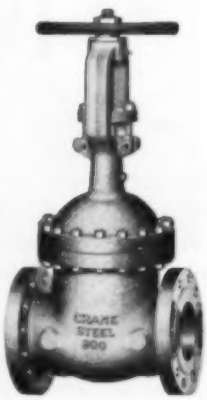

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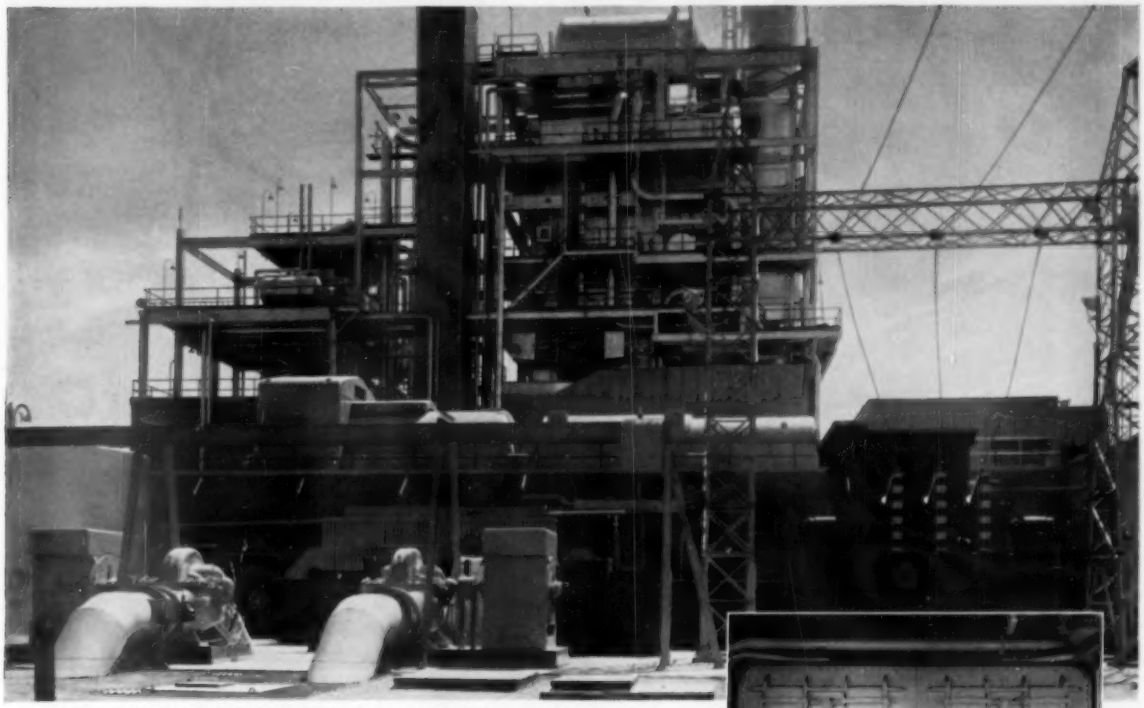


Close-up of OG&E Arbuckle Station at Sulphur, Okla., showing two Ingersoll-Rand circulating water pumps delivering cooling water to the cooling tower.

PUT into service early in 1953, the 81,500 kw Arbuckle Station of Oklahoma Gas & Electric Co., at Sulphur, Oklahoma, is the first completely outdoor-type station — as well as the largest single generating unit — in the OG&E system. More than two years of successful operation have now demonstrated the soundness of the station design as well as the dependability of all components.

Ingersoll-Rand equipment in service at Arbuckle Station includes the following:

One 60,000 sq. ft. surface condenser with I-R air ejector and priming ejectors.

Two circulating pumps, 30,000 gpm, each driven by 750 hp 450 rpm motor (shown in photo above).

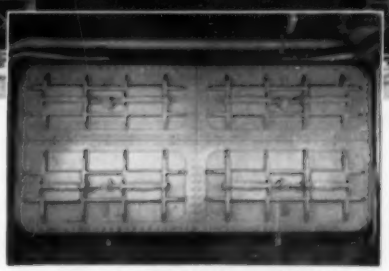
Two 1300 gpm vertical condensate pumps.

Two 5-stage double-case type boiler-feed pumps, 755,000 lb/hr, 1235 psi head.

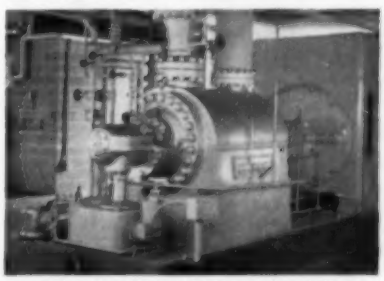
Two 300 gpm make-up pumps.

One I-R fife pump, and one 200 cfm service air compressor.

For power plant equipment of proved dependability and long-range economy, specify Ingersoll-Rand. Your I-R representative will be glad to assist you on any pumping, compression, evacuation or condenser problem.



Ingersoll-Rand two-pass, 60,000 sq. ft. rectangular surface condenser installed beneath the 66,000 kw turbine generator.



One of two I-R 5-stage double-case type boiler-feed pumps, driven by 1750 hp 3600 rpm motor.

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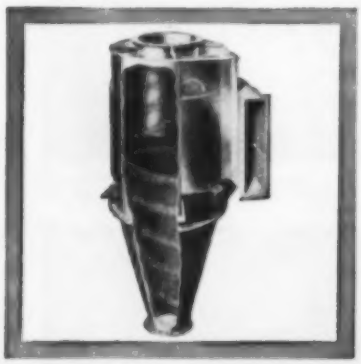
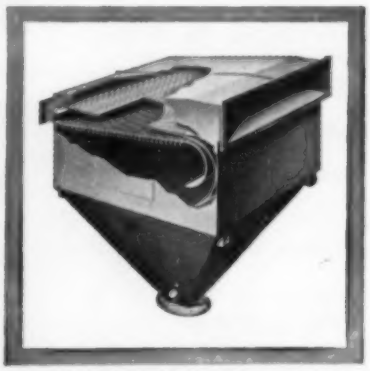


Buell Cyclones offer two "extra-efficiency" advantages: (1) exclusive shave-off which harnesses double-eddy and puts it to work, and (2), large diameter design which eliminates clogging.

Besides eliminating efficiency drops and "shutdowns" due to electrode breakage, Buell's unique Spiralectrode permits higher and more constant emission, extra efficiency. Also, Continuous Cycle Rapping—another Buell exclusive—keeps electrodes constantly clean for maximum performance!



Buell's Low Resistance Fly Ash Collector combines top efficiency with low draft loss, for natural or forced draft installations. Ideal for boilers from 100 to 2000 BHP.

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Editorial

Beyond Coordination—What?

On the cover of the program of the highly successful Nuclear Engineering and Science Congress and International Atomic Exposition held in Cleveland in December are these words: "Coordinated by Engineers Joint Council for 26 engineering and scientific groups." This is not the first time that a large technical meeting involving many professional societies has been coordinated, but it may well be the first time that the interests of unified programming have so effectively superseded considerations of society autonomy, seniority and prerogatives.

To be more specific, the five-day technical program was made up of fifty sessions averaging five papers each. The program committee under the experienced chairmanship of Professor Donald L. Katz of the University of Michigan arranged the papers in each session according to subject matter. The results were as follows:

16 sessions with papers sponsored by one society
17 sessions with papers sponsored by two societies
13 sessions with papers sponsored by three societies
4 sessions with papers sponsored by four societies

The atom has been alternately heralded as the forerunner of a new era of peace and condemned as the potential destroyer of civilization as we know it. But in Cleveland the atom appeared in a new guise, that of providing impetus toward the unification of the engineering profession. And it did this because of a magnanimous gesture of the Nuclear Engineering Division of the American Institute of Chemical Engineers which had sponsored the first International Nuclear Engineering Congress at the University of Michigan in June of 1954. Here was a case of a professional society having established priority in sponsorship and programming in a new and important technical area. Instead of selfishly maintaining these prerogatives, the American Institute of Chemical Engineers generously offered to work with the Engineers Joint Council in planning wider engineering and scientific society participation in the 1955 Nuclear Engineering and Science Congress. The enthusiastic participation of 26 organizations in the recent Cleveland meeting attests to the wisdom of this decision.

Intersociety cooperation of a type unheard of a few years back was achieved under the effective leadership of the general chairman of the Congress, Dean John R. Dunning of Columbia University and his working committees from the participating groups. As a result of this, unification of the engineering profession has received a new impetus and the Engineers Joint Council has achieved greater stature. But coordination is only a first step, though an important one. Success of the Nuclear Engineering and Science Congress should encourage the Engineers Joint Council to take another bold step forward in the ultimate quest for unification of the engineering profession.

Supplies for the Nuclear Field

Year's end always brings with it the inclination to look back on past achievements and failures and, at the same time, to try and guess at what lies ahead. The cover picture of this issue portrays the final model of the Calder Hall Station of the United Kingdom Atomic Energy Authority. This installation slated for operation in 1956 is believed to be the first central station nuclear power plant to go on the line. It will, of course, usher in a new era albeit its design is already appraised as an example of an earlier experimental stage. Just how rapid the rise in relative importance of the nuclear energy source to the power industry as a whole will be dependent to a marked degree upon the ability of the manufacturers supplying the industry to keep pace with developments. It is this conjecture that leads to speculation.

When the government under the various security regulations in force since World War II restricted all study and development of nuclear energy to its own sponsored agencies, firms of all stripes competed actively on any and all supply requests let out for bids. Some of these firms knowingly took a loss on various projects to establish a position in the nuclear energy field. That stage we feel is pretty well past. The necessary manufacturing tools and techniques for the presently proposed nuclear reactors are known and realistic bids can be made. The manufacturer has to risk his capital in these tools and techniques and unless his bids are realistic enough to permit a fair margin of profit the developmental program with private industry participating will grind to a halt. This to our way of thinking would be unfortunate if not disastrous.

The shape of things to come then, as we see it, is an increasingly higher capital stake to get into or stay in the nuclear energy equipment supply business. Along with this heavy capital outlay there will be a drop-off in the number of manufacturers capable of or willing to undertake the competitive risks that seem inherent in this relatively new field. The end result could well be a battle of the giants. However, such a battle carries with it the elements of active competition which begets progress in its own right.

Projected Cost Outlook for Conventional Power*

By J. H. HARLOW

Mechanical Engineer, Philadelphia Electric Company

New fuels and new methods of power generation quite naturally engender enthusiastic proponents. At times, however, economic reality must be introduced to bring the picture into perspective and balance. This is what an experienced power engineer whose company is actively engaged in pioneering ventures in power plants utilizing both conventional and nuclear fuels has sought to accomplish in the article that follows.

You have heard a great deal of very encouraging information regarding the probable costs of producing electric power from atomic energy in the very near future. I am sure that you are thrilled and excited about the prospects of putting this new fuel to work in our power plants just as I am, in so far as I firmly believe that atomic energy will be a basic fuel of the future. However, in the long run, these plants will not be built until they can prove a dollar advantage when compared with so-called fossil fuel plants. This dollar advantage will have to be very real and reasonably well assured and must include all costs such as insurance, wastes disposal, true costs of fuel and fuel preparation and taxes.

The first generation of atomic-electric power plants will show us many, many means for reducing costs, for cutting corners and for making improvements. They also will probably show us many new problems some of which, likely as not, we have never dreamed existed in spite of all the very capable talent which has been assembled on this work. This generation of plants cannot and does not need to justify its existence on a competitive basis. Neither will the second generation of plants be required to show any real economic advantage, although I would suspect that in certain areas there is a very good chance that they will. However, I am of the opinion that from the third generation on, atomic-fueled plants will be installed only when and where they can be shown to produce a definite advantage at the bottom of the year's financial statement.

This does not mean to imply that in two generations of experimental and semi-experimental nuclear plants we will need to learn everything there is to know about such plants or that there will be no opportunity for improvement from that time forward. It only means that costs must be reduced to the point where they are approximately equal to that of the conventional plants in the higher cost areas.

* Presented before the fourth annual conference on Atomic Energy in Industry sponsored by the National Industrial Conference Board, October 26, 1955. Transcripts for all sessions of the three-day meeting may be obtained for $15 from the Conference Board, 460 Park Avenue, New York 22, N. Y.

Now in order to appraise the competitive situation facing the growth of nuclear power plants, I have been requested to establish a frame of reference by presenting some facts regarding present-day costs of producing electricity in fossil fuel plants of current design and by discussing briefly some of the developments which may be anticipated in the near future. By near future, I mean the interval of say five to fifteen years during which the first and second generation of atomic-fired boilers will have been designed, built and tested.

If you look at a map of the United States on which fuel costs for the different states are marked, you would note very quickly that fuel costs vary widely in different parts of the country. In New England, in the Mountain states, around Chicago and in a few other areas fuel costs as supplied to the boiler at the present time are in the order of 35 cents per million Btu. In the area roughly comprising Texas and the lower Mississippi Valley, fuel costs at plants are as low as 10 or 15 cents per million Btu. Thus just within our own country the range of cost of heat to be delivered to our turbines is at least three to one; and though I am only slightly familiar with costs elsewhere in the world, I am sure there are many places where costs run as high as 80 cents per million Btu.

Relation of Investment Costs to Fuel Costs

Now it is an interesting circumstance that, in a rough sort of way, investment costs per unit of capacity in the low fuel cost areas run less than they do in the high cost areas. This is the consequence of two very different causes. In the first place, higher fuel costs have justified more efficient and therefore more expensive heat cycles and the installation of more expensive heat traps. But more importantly, in the second place, it so happens that the fuels in the least expensive areas are gas and oil which do not require heavy investment in coal handling facilities, bunkers, pulverizers, ash handling facilities, fly ash collectors and the like. Also these areas enjoy a warmer and sunnier climate on the average and less building is required. These items put together will total from $25 to $50 per kw. There is a further penalty against high-fuel-cost areas, namely, higher labor rates and material and equipment costs. Not only is it more expensive to build comparable plants in these areas but costly automation is likely to be more extensive.

So with these factors in mind, I would like to consider the actual present day situation relative to the cost of electric power production in two widely separated areas by considering typical plants in those areas in order that a basis may be set in your minds as to the nature of the competitive situation with which nuclear power plants would be faced today. These plants are near the top and bottom of the scale of costs per kwhr in U.S.A.

For example, there is a plant in the Northeast area which cost about $180 per kw of capacity and which burns coal costing between 35 and 40 cents per million Btu. This plant, for obvious reasons, has been designed for top efficiency and includes all the latest developments pointed toward that end. The heat rate is less than 10,000 Btu per kwhr. It is in a northern urban area and therefore must be equipped with very expensive dust traps and a completely enclosed building in order to avoid becoming a nuisance in the neighborhood and to guard the equipment and personnel against severe winter weather. To produce electricity in this plant costs about 8.0 mills per kwhr, made up of $4^1/_2$ mills for fuel and other operating costs and $3^1/_2$ mills for capital costs, based on a $12^1/_2$ per cent return and 75 per cent load factor.

At nearly the other end of the scale is a new plant in the South Central part of the country. Here the fuel is natural gas which costs only 12 cents per million Btu. With such cheap fuel, it is not expedient to spend so much for the ultimate in efficiency so the heat rate of this plant is 12,000 Btu per net kwhr. Also gas fuel does not require expensive fuel handling and preparation equipment nor are dust collectors and ash transporting devices necessary. Further, the weather is mild and the plant is totally outdoors. Thus it was possible to build this particular plant for about $120 per kw of capacity. In this plant the overall costs are about $4^1/_2$ mills per kwhr, made up of $2^1/_4$ mills for fuel and other operating costs and $2^1/_4$ mills for capital, computed on the same basis as for the Northeast plant just described.

Here, therefore, is a range of nearly two to one in electricity costs to be found within the limits of our own country.

Competition with the Best, Not the Average

Now, of course, *the nuclear plant must compete in its economic justification with the best current design and not with the average in operation at any given time. And this is not a static condition.* Since 1905 heat rates have decreased from about 40,000 Btu per kwhr to less than 10,000 Btu per kwhr, and the end is not yet. For example my own Company, the Philadelphia Electric Company, now has on the boards a supercritical pressure power plant which will set new standards in size and efficiency.

And this plant does not stand alone in representing the latest in electric power plant design. The first full scale unit to operate above the critical steam pressure is now under construction at the Philo Plant of the American Gas & Electric Co. system and a third one is on order for the Cleveland Electric Illuminating Co. All three units will produce electricity at 8500 Btu per kwhr or less. The Philadelphia Electric Co. unit being the largest of the three, namely 325,000 kw, and operating at the highest pressure and temperature, 5000 psig and 1200 F, will be the most efficient, having a design heat rate close to 8000 Btu per kwhr.

One might think that such a plant would cost substantially more than plants designed for the current steam conditions. Actually, however, the unit cost has been increased very little if at all.

Now you may wonder, with atomic power just in the future, why we are spending so much effort toward greater economy of conventional fuels? The answer is really twofold.

In the first place, it is traditional in the electric power game never to be satisfied with past results. There is always the opportunity to do a little better whether that be in reducing costs, or making machinery a little more dependable, or of improving the efficiency. The supercritical unit is another milestone along the road. As an example of what has been accomplished, the heat rate of this unit is about one-third of that of the industry thirty years ago. If no advance had been made, the estimated electrical demand in the U.S.A. in 1965 would require about 1000 million tons of coal a year; at the efficiency of the supercritical unit, the requirement would be only 350 million tons of coal per year.

And in the second place, for a great many years fossil fuels will continue to supply the great bulk of the electric power used in this country. Even the most optimistic estimates seem to indicate that by 1980 or 1985 possibly as much as 25 per cent of the fuel used may be nuclear and that possibly 50 per cent of the new capacity installed at that time will have atomic furnaces in the boilers. Even when all new capacity depends on fission or fusion, the existing plants will continue to operate and to consume coal, oil or gas. Under these circumstances and when it is considered that our reserves of conventional fuels are very limited, it is apparent that it is vital to conserve our supply as much as possible, and this can be done most effectively by designing for the best possible thermal efficiency.

Therefore, and this is the point I am endeavoring to make, *the fossil fuel plants of the future will be more efficient than those of the present and the competitive situation facing the nuclear plants will be more severe as time goes on.* For example, if the heat rate of Philadelphia Electric Company's new plant were used in computing the costs for the Northeastern plant cited earlier, the cost to produce a kwhr would be down by $^3/_4$ mill.

Foreseeable Improvement in Conventional Plants

And this is not the end of the foreseeable future improvement in fossil fuel plants. Already the designers are working on a combination gas turbine and steam cycle which will further reduce the fuel costs of the Northeastern plant $^1/_4$ mill per kwhr. Thus, say in 15 years, it is reasonable to expect that even in areas where coal costs 35 cents per million Btu, the cost of delivered kwhr will be in the order of 7 mills, down 1 mill from present. How much further efficiency will be improved and therefore costs reduced, only the future can tell; but unless the zeal of power plant engineers and designers is much less then than now or in the past, it is safe to say that more and more ingenious ways will be discovered for doing an even better job.

In order to complete this look, we should ask ourselves, what will be the future trend in construction costs and fuel costs for conventional plants?

The Handy-Whitman index of public utility steam station construction costs indicates that from 1940 to 1955 costs more than doubled. However, during this same period, the cost per kw of installed capacity rose only about 30 per cent. In fact, since 1950, the cost per kw has been reduced slightly for new large plants. As most of you know, the fact that we have kept the cost

per kw down resulted from larger unit sizes, elimination of spares as equipment became more reliable, less expensive buildings, more outdoor design, greater efficiency, etc. Our estimates of costs of the more advanced designs indicate that the unit cost will be increased little if any.

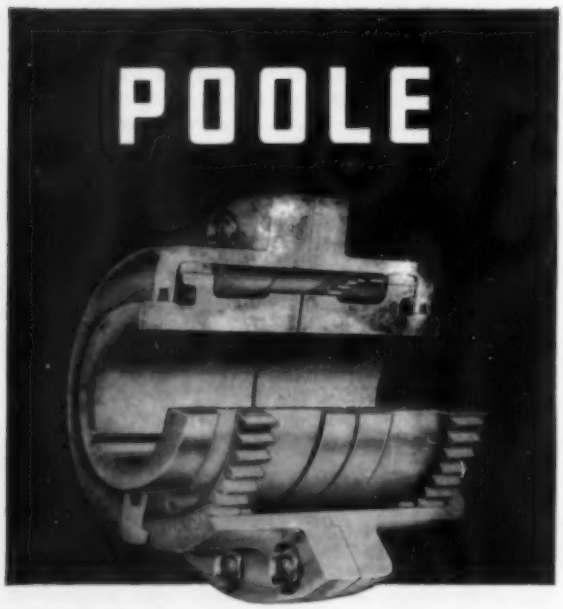
Of course, *the improvements which the steam engineers are able to make should be of vital interest to the atomic engineers also*, for as soon as the atomic engineers are able to take advantage of higher pressures and temperatures in the steam cycle, not only will the atomic fuel costs go down but so will the atomic investment costs. If the steam cycle of the atomic plant can be made to operate at 8000 Btu per kwhr instead of 12,000 Btu per kwhr as is presently being considered, a given reactor may be capable of producing one and one half times as many kw of electricity and therefore the cost of the atomic boiler per kw may be reduced one third.

The other factor which should be injected into a discussion of the competitive situation between atomic and fossil fueled plants of the future is this: our supplies of fossil fuels are very limited and therefore the price is bound to rise in the not too distant future. And strange to relate, our reserves of the lowest cost fuels are said to be the smallest and therefore prices in this area may be expected to increase first. When this happens the pressures will be very great on the atomic engineers to have a completely satisfactory atomic plant ready, because then our supply of the fuels which we call conventional today will be in short supply.

Nuclear Energy and the Cost of Power

But one thing is certain. When the cost of producing kwhr someplace is less expensive with nuclear fuel than with fossil fuel, then a nuclear plant will be built in that place. And the spread in cost need not be very large to cause the building of the plant in that place. And this gives me an excuse to make an observation relative to a misunderstanding which the public seem to have and which I believe we should undertake to correct. Frequently statements have been and are being made about the "abundant and cheap" electricity to be had in the future as a result of the use of the atom for its production, as though to imply that electricity is "restricted and expensive" today. I suspect from the conversations I have had with certain non-power folks that they have been taught to expect that, sometime soon, their electric bill will be cut in half or more. All of us here know, of course, that the bulk of the costs of providing service, particularly to the small business and residential customers, is in the cost of the money needed for the physical plant to supply the service and that the very small changes which atomic fuel may create will have an insignificant effect on the customer's bill.

The most important thing is this, that we can look forward to the long range future in the confidence that when the fuels we conventionally use today are gone or too expensive, we will have a supply of a new fuel of adequate quantity to assure us that electric power will continue to be "abundant and cheap."



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY WOODBERRY, BALTIMORE, MD.

C-E Establishes Nuclear Engineering Center

Combustion Engineering, Inc., has contracted for the purchase of a 530-acre site in Windsor, Connecticut, on which it will build a Nuclear Engineering and Development Center.

The Center will comprise facilities for the complete design and development of nuclear power reactors, for the construction of reactor cores, and for the manufacture of related atomic fuel elements. Costing upwards of 5 million dollars, the Center will begin operations late next year and by 1957 will employ several hundred people in its various departments, largely engineers, scientists and technicians. Stone & Webster Engineering Corporation have been engaged to serve as architects and engineers.

A large engineering and administration building, a critical experiment facility for studying the physics and nuclear characteristics of reactor cores, a "hot" laboratory and a fuel element fabrication plant, together with related metallurgical, chemical and physical testing laboratories, are to be erected. Personnel of the company's Nuclear Power Division and Reactor Development Division will be transferred from New York to Windsor as soon as the buildings are ready for occupancy.

All manufacturing facilities at Windsor will be of the highly specialized type required for the production of "light" components such as reactor internals, control mechanisms and the like. The facilities will be designed to conform to all A. E. C. safety requirements.

All "heavy" reactor work will continue to be done in the Company's main manufacturing plant in Chattanooga where reactor components thus far produced by the Company have been fabricated.

ASME Annual Meeting In Review II—

In the earlier report of the recently concluded annual meeting of the ASME carried in the December COMBUSTION the highlights of the meeting were given and many of the papers of direct interest to the power field. There were, however, a number held over for space reasons that are abstracted below.

Power Plant Maintenance

G. V. Williamson, Union Electric Co., selected for his paper "Maintenance Control in Steam Power Plants." As Mr. Williamson saw it one of the ever-important problems in the operation of steam power plants is the establishment, operation, and continuing evaluation of a realistic plant-maintenance program. Such programs are difficult to evaluate because plant variations in operating conditions, equipment, fuel, and many other factors are of such a nature they cannot be even empirically compensated in any study. On the other hand, with improvements in plant heat rates gradually approaching the point of diminishing return, the power-plant designer or operator must look further into the possibilities for improvement in all areas of operating cost. As all power operators know, the maintenance program is at the heart of successful operation. It is a traditional rule of thumb, and current results bear it out, that this program will cost each year roughly 2 per cent of the plant investment. With the large power building program of the last ten years, and the one now in progress, this 2 per cent item is worth more attention. Maintenance control is an area where considerable work remains to be done and at Union Electric it has been placed higher on the priority list.

Simply stated, the author's company, approaches this problem from the following aspects: (1) Station design—where a good maintenance arrangement starts through liaison between design and operating groups. (2) Test engineering—with reliance on a continuing test program for support of a maintenance philosophy approaching breakdown maintenance. (3) Cost accounting—with records continually studied by engineer analysts. Highly detailed records are now available for 10 years and provide some standard of performance. (4) Supervisory training—with improved productivity and improved quality as an objective. (5) Operating-maintenance rapport—plant management stresses interdependence. The paper reviewed the various points in each of these categories that might be of help in the ultimate success of any maintenance program.

The paper "Maintenance Factors Affecting Production Costs" by **W. F. Oberhuber** and **C. W. Watson,** Philadelphia Electric Co., began by considering total production costs and after removing the cost of fuel from the total production cost, the remainder included the costs of supervision and engineering, plant operating labor, supplies and expense, and maintenance. In large, predominately steam systems maintenance represents approximately 50 per cent of these costs. The maintenance portion of production costs is the relatively unexplored field wherein lies the greatest opportunity for potential reduction of total production costs.

When purchasing a new unit engineers have been able to justify additional capital expenditures for such automatic equipment through economic studies which accurately evaluate the resultant operating labor savings. At present, when a company looks over a proposed design it may recognize certain features, that if retained, might result in excessive maintenance. If detailed maintenance costs could be predicted accurately, they would be weighed against capital costs when purchasing new equipment, thereby obtaining optimum selection of equipment from a total cost viewpoint. It is questionable whether we know the parameters necessary to evaluate certain maintenance costs. It appears that a great deal of further study and discussion is necessary to get the greatest use of the mass of maintenance costs data all operating utilities possess.

In striving toward this end, it is necessary to analyze the factors that constitute maintenance costs. As the authors see the picture now, it appears that the major factors affecting these costs are: original design, management policy, planning, organization and cost-accounting system. Each of these points were discussed.

V. F. Estcourt, Pacific Gas and Electric Co., in the paper "Plant Management and Other Factors Affecting Maintenance Costs in Steam Generating Stations" referred to his earlier paper "Manpower and Other Factors Affecting Operating Costs in Steam Generating Stations" wherein he established fuel costs as representing 35 per cent of the total production cost and maintenance and operating charges amounting to about 10 per cent. The obvious advantage of higher thermal efficiencies were covered in the earlier paper. In this one Mr. Estcourt turned his attention to maintenance.

Although direct maintenance costs in thermal power stations comprise only a small percentage of the total cost of production, replacement power costs while a generating unit is out of service for maintenance, to Mr. Estcourt's thinking, is also chargeable to the overall cost of the job. This may amount to considerably more than the entire cost of the repairs. The control of maintenance cost is concerned principally with those factors which influence the ability of the plant to stay on the line, and this includes a wide variety of problems relating to equipment design, plant layout, types of fuels, manpower utilization and management problems.

The limited statistical value of the term "operating availability" was discussed, and the concept of "relative mechanical availability" was introduced. Increasing technical and physical complications, together with larger unit sizes and greatly expanded generating systems, suggests the need for a redistribution of responsibilities at the plant level. This has created a demand for higher grade engineering graduates with academic qualifications more suited to the special problems of thermal power production, and a larger degree of cooperative effort between the utilities and the universities also appears desirable.

Two highly interesting appendices, one on equipment design factors and the second on a method of computing man-hours for different work schedules was included.

Water Treatment

The paper "Status of Demineralizing for Treatment of Boiler Feedwater in Today's Power Plants" by **V. J. Calise,** provided an interim report on some of the present trends, problems and practices as well as results obtained from the use of multi-bed and mixed-bed ion exchange demineralizers in the production of low solids boiler feedwater in today's industrial and central station power plants.

The author referred to and included data on case histories in the literature, mentioned successful results as well as categorized some of the problems and the difficulties and pointed up the latest developments and trends in design and application that may be of value to the power plant engineer considering such installations in new power plants. In carrying out this report Mr. Calise has furnished the industry with an excellent bibliography on the subject of demineralization in the power field.

Pumping and Piping

"Effects of Adjacent Piping Configurations on Control-Valve Characteristic and Capacity" was presented by **G. F. Brockett,** Fischer Governor Co., and **W. J. L. Kennedy,** Stone & Webster Engineering Corp. In many instances the care used in specifying control valves in the engineering stages of a project, had the efforts partially nullified by poor installation practices. In this paper the authors review several of the more common control valve-manifold arrangements and point out the ill effects where they occur. It is hoped those responsible for the selection of control valves will be encouraged to extend their responsibility to include a review of the actual installation details.

In the test results the basic capacity of the control valve is plotted for reference. This capacity is measured by taking the pressure drop across the control valve plus the pressure drop due to the two necessary reducers which are located at the inlet and outlet flanges of the control valve. A discussion of standardization for test manifolds for measuring control-valve capacities was presented in a companion paper at this symposium.

It is also common practice to include the pressure drop across the entire control-valve manifold under the pressure differential available for control. That is, if 10 psi is allowed for control, 2 psi of this may be used in the piping immediately adjacent to the control valve. The authors have followed this practice in the test results which follow; the control valve and its adjacent piping have been considered a system and treated as a unit in assigning pressure drop and calculating flow. The authors felt it seemed obvious that a reduction in effective capacity of the control valve will result; the fact that this is obvious does not insure that its effects will be compensated for. If it were not true that many control valves are oversized by duplication of safety factors, this effect would be more commonly noticed.

While the results of these tests in so far as capacity reduction is concerned could probably have been predicted, the changes in valve characteristic are not predictable. The present tests used plug valves; other types of valves and fittings could have been used and the results obtained would then depend upon the flow pattern and pressure loss characteristics through them.

It is common practice to reduce the size of the inlet and outlet blocks, as well as to add elbows in the manifold. It can be expected that this will result in impaired capacity and characteristic. The press of time, however, limits the test data which can be included with a reasonable expenditure in time and money.

H. A. Stahl and **A. J. Stepanoff,** Ingersoll-Rand Co., presented the paper "Thermodynamic Aspects of Cavitation in Centrifugal Pumps." They pointed out that existing knowledge on the control and avoidance of cavitation in pumps has been entirely experimental and statistical in nature. Most of the data have been gained on tests for which cold water was the medium. Extension of these data to other operating conditions and other sizes are made by means of the similarity law. Only the dynamic aspects of the machine are taken into account and the assumption is that the data gained from cold-water tests apply in all cases. However, there is evidence that thermodynamic properties of liquids are additional variables which can result in deviations from the dynamic laws of similarity. The purpose of this paper was to elaborate on the thermodynamic aspects of cavitation.

"Water-Column Separation in Pump-Discharge Lines" by **R. T. Richards,** Ebasco Services, Inc., stated that water-column separation is a phenomenon which will come into increased prominence with the extensive use of vertical pumps. Once water-column separation has occurred the limits to surge pressures imposed by the elastic theory in a continuous column no longer apply.

It is the first phase in the development of one of the most destructive types of water-hammer surge in pump discharge pipelines. Following a fast valve closure or pump tripout the sudden pressure drop downstream from the valve or pump may be severe enough to bring about a temporary vapor-pressure condition, and possibly the formation of a void in the pipeline. The subsequent closure of this void often results in violent surges well above any possible transient pressure rises in a continuous water column. In spite of the possible seriousness of this surge condition it has seldom been discussed in technical literature.

This paper briefly described the nature of water-column separation, the physical factors which bring it about, and the equipment effective in controlling it. The discussion was illustrated by field test data taken from typical water pumping plants associated with the cooling-water supply for steam electric stations.

Fuels and Firing

The Fuels Division's principal papers were all submitted in one day at three separate sessions. They ranged from the problems of ash fouling to oil fuel im-

provements and finally the flow characteristics of aerated fine coals. A number of co-sponsored papers of general fuel interest appear under Gas Turbine and Steam Power sections elsewhere in this report.

John R. Michel, Commonwealth Edison Co., and **L. S. Wilcoxson,** Babcock & Wilcox Co., presented a paper entitled "Ash Deposits on Boiler Surfaces from Burning Central Illinois Coal" covering their companies' joint study over the past five years of the basic causes of ash deposition on boiler surfaces. The particular emphasis of the study was to develop effective and economical means of controlling ash deposition when burning Central Illinois coals.

Based upon experiences with the Calumet 20-A pilot cyclone-fired installation of 1943, Commonwealth Edison, felt they had found the answer to their slagging problems. So they requested a return to the boiler design of close-spaced tubes with no provision for hand lancing boiler and superheater surfaces in operation. Later experience did not justify this optimism and hence an intensive campaign was launched to develop an effective control of ash deposition. Four principal approaches seemed promising: (1) more effective cleaning methods of heat-absorbing surfaces, (2) reducing flue gas temperature entering the superheater, (3) removing harmful constituents in the coal before it burns, (4) changing the undesirable characteristics of the fly ash with additives.

At Fisk Station continuity of operation was increased as a result of the study of these approaches from a few months to a year on cyclone-fired units. Improved cleaning power and range of soot blowers, increased reliability of the blowers by improvements in the control system, maintaining furnace cleanliness with wall blowers, maintaining proper fuel-air ratio with combustion controls, water-washing superheaters, use of gas tempering constitute the major specific factors that permitted achieving this increase.

The authors' companies believe that the alkalies in Central Illinois coal are the main cause for the bonded deposits and they can be removed by washing but not economically. Additives also offer promise but more work in the field is needed. Closer control of boiler operating conditions seem more important as steam temperatures increase and continuous operation at high ratings becomes more common.

D. H. Barnhart, Babcock & Wilcox Co., and **P. C. Williams,** also of Babcock & Wilcox Co., followed up the Michel, Wilcoxson paper with one, "The Sintering Test, an Index to Ash Fouling Tendency," which reported on one area of information arising from the mutual study project broadly described in the Michel et al. paper. As part and parcel of the study the relationship between various operating conditions, fuel, excess air, temperature level, were examined in part by observing the performance of several boilers over long periods of operation. But the number of variables involved so upset the expression of results in quantitative terms that a new index or characteristic of the basic fuel was sought.

The belief developed that a study of the group reactions producing about the same conditions as an ash deposit on a superheater tube would provide a possible index to the ash fouling tendency of a coal. As a result a special sintering test was developed and the authors describe it in their paper. After working out the sintering method and standardizing it the index was used to evaluate experimentally some of the more important factors in ash fouling. A severe fouling and also a non-fouling coal were tested. Similarly a study of ash from the sintered sample and that from an actual boiler were observed and growth rates noted. The factors held important, temperature of the ash deposit and the time it was allowed to remain on the tube, were especially watched. A measure of the sintered strength of a sample ash formed by the suggested method gives an indication of the effect of additives as a control or the need for a definite sootblower installation to keep boiler surfaces reasonably clean.

The third paper on this session, "Bonded Fireside Deposits in Coal-Fired Boilers—A Progress Report on the Manner of Formation" by **C. H. Anderson** and **E. K. Diehl,** Babcock & Wilcox Co. discussed the composition and formation of ash deposits on convection surfaces of coal-fired steam boilers. The innermost layer of these deposits as others have reported, seems to have different chemical and physical characteristics than the bulk of the deposit, and to the authors it was apparent that this layer was an important factor in bonding the deposit to the tubes.

The chemistry of the compounds which make up the inner layer were investigated and the role which this layer plays in the formation of the overall deposit was described. Sulfated iron and aluminum in the form of complex alkali sulfates were held responsible for the low melting characteristics which cause the formation of the tightly bonded inner layer. These compounds were then synthesized in the laboratory from fly ash constituents and a synthetic flue gas.

Tests using an air-cooled probe inserted into an operating boiler showed that the inner layer of deposit resulted from a slow reaction between sulfur gases and the initial dry dust on the tube. After a period of time this layer attained sufficient thickness to provide a foundation upon which the outer bulk of the deposit would build up.

Except for a widely varying sulfur content, the outer deposit, the authors stated, resembled fly ash in its chemical composition. It increased in size and strength through a sintering action, with the alkali sulfates and silicates apparently the principal bonding agents.

Oil Fuel Advances

R. P. Gilmarten, Gulf Oil Corp., **W. A. Horme** and **B. R. Walsh,** Gulf Research & Development Co., combined in the paper "Upgrading Burner Performance of Distillate Fuel Oils by Hydrogen Treatment." In it the authors claimed that the recent advent of catalytic reforming of crude oils to produce gasoline permits, for the first time, a means of upgrading the distillate fuel oils as well as the gasoline. In these latest methods a reaction process between hydrogen and the fuel oil distillate streams is carried out in the presence of a catalyst at elevated temperature and pressure.

From the use of hydrogen the distillate fuel oil, according to the authors, is improved as follows:

Sulfur content gives an 80 to 90 per cent desulfurization including essentially complete removal of mercaptan products. These last named cause an objectionable odor and to combat the odor certain treatments were

employed in the past that later created storage stability and fuel compatibility problems.

Carbon residues for the 10 per cent bottoms of crudes are said to be lowered 80 to 90 per cent and somewhat similar improvements are held for blends of cracked and uncracked distillates.

Color stability is said to be superior for hydrogen treated distillates.

Something like a 3 degree A.P.I. gravity increase has been obtained for hydrogen-treated catalytically cracked distillates and about 1 degree A.P.I. for virgin straight-run distillates.

Practically all acids such as naphthenic acids are removed. Further, there is said to be greatly intensified resistance to sludge formation in storage. Water separation characteristics are also improved.

A second paper, "Improvement of Distillate Fuels by Additive and Refining Techniques," by **D. P. Osterhout, J. P. Kirchner,** and **W. R. Schwindeman,** Socony Mobil Laboratories, discussed a somewhat different approach to the problems of fuel oil sludge and the formation of transparent gel-like deposits resulting from the reaction of mercaptan sulfurs in the oil with the copper in the brass parts of the fuel system. These authors defined the causes of the problem and then commented on the effects of treating oils and specifically using additives to avoid the problems so defined.

Those additives called dispersants or anti-screen clogging agents allow the sludge to pass through strainers or filters but they may produce two to three times as much sludge as an oil without these additives. The second general type of additive, the sediment inhibitor, eliminates or reduces insoluble sludge formation. But, unfortunately, its usefulness as a lone agent is limited and an anti-screen clogging additive must also be employed. The temporary relief they give is offset by possible problems in the operation of the equipment.

In summation the authors surprisingly return to the contention that the proper combination of additives with treating will eliminate the sludge sediment and sludge dispersal problems existing in certain oils.

"The Filtration of No. 6 Fuel Oil to Remove Undesirable Trace Metals" by **C. H. Shields, Jr.,** General Electric Co., covered the studies of the removal of trace metals from No. 6 fuel oil by filtration primarily for gas turbine service. As the author stated, residuals such as No. 6 fuel oil offer attractive reductions in fuel costs which are often not realized because of disadvantages such as high viscosity, high ash content, and excessive frictional wear and corrosion tendencies. In the field of gas turbines, for example, fuel-cost reductions are offset by losses due to seriously accelerated corrosion of buckets and other high temperature turbine parts. Studies have traced this trouble to metal or metal-ion impurities in the oil such as sodium, vanadium, and calcium which form a corrosive, sticky ash. These impurities have their origin not only in the crude oil itself, but also in chemical refining processes and contamination by sea water during shipment.

A number of processes planned to remove these metals or inhibit their corrosive activities have been investigated by gas-turbine manufacturers and others, and the author furnished a bibliography on these activities. One of the possible methods which was selected for study was filtration.

Materials were first evaluated in batch-filtration tests. One of the higher solids content No. 6 fuel oils was chosen as the test oil. It had a viscosity of 1150–1275 centistokes at 100 F, a water content of about 0.2 per cent, and sodium and calcium concentrations up to several hundred ppm each.

Using a vertical leaf laboratory precoat filter, the oil was passed through precoat cakes deposited from transformer oil slurries of several grades of diatomaceous earth and calcined clay. Analyses for trace metals soon indicated at least a partial solution to the metal problem, but as was anticipated, cake plugging was serious. Analysis of precoat cake strata indicated primarily surface collection of contaminants, and further experiments suggested that the problem of plugging might be met by use of a continuous rotary precoat filter, in which a doctor knife constantly removes surface layers of the precoat filter cake as they become plugged.

It was found that (1) precoat filtration through diatomaceous earth can reduce the sodium concentration in No. 6 fuel oil to about 2 ppm from original concentrations of over 200 ppm; (2) calcium, iron, aluminum, lead, and magnesium, as well as sediment and total ash are substantially reduced; (3) present data indicates that the process using a continuous rotary precoat filter is economically feasible.

Coal Movement

The results of the studies carried out by the Locomotive Development Committee and Bituminous Coal Research, Inc., to determine the effect of varying degrees of aeration upon the flow characteristics of coals of varying size consists and moisture content were made the subject matter of the paper, "Flow Characteristics of Aerated Crushed Coal" by **C. H. Marks, Peter R. Broadley,** and **John I. Yellott.** As the authors stated air passed at a low velocity through a bed of crushed coal produces significant changes in the flow characteristics of that coal bed. Most important to the authors were (1) a change in the angle of repose from as high as 50 degrees to as low as two degrees, (2) a large increase in rate of coal flow through an opening in the bed. In short the material took on some of the characteristics of a viscous fluid and the effects became more marked as the minus 50 mesh fraction of the coal particles increased.

The paper discussed the application of this aerated process to the discharge of the crushed coal from flat bottomed bunkers and then attempted to establish criteria for predicting flow characteristics of crushed coal when the size consist and moisture content were known. The authors explained at length testing equipment, methods, determination of data and the coals tested, plus more specific details on the static and dynamic behavior of the tested coals. The effect of size consist and moisture content were well discussed.

High Temperature Steam Generation

To obtain a practical and long-time demonstration of of the suitability of certain new alloys, developed during

and after World War II, for higher steam temperatures, a superheater test element was constructed and installed in an operating boiler at Twin Branch Plant, receiving steam at 2000 psi, 950 F and discharging 1250 F steam at the outlet. Field operation began in March 1950 and an account of the experience gained during the first two years of operation was presented in a previous paper. A second paper dealt with the succeeding two years of operation and included preliminary information obtained from the metallurgical examination of a number of samples removed from the element after nearly 7000 hr of operation. The test element was finally removed from service in May 1954, because changes in operating schedule reduced the rate of accumulation of service time and prevented the effective continuation of the test. The finding when this test element was removed and examined supplied the data for the paper "Experimental Superheater for Steam At 2000 Psi and 1250 F—Report After 14,281 Hours of Operation" by **J. Hoke** and **F. Eberle,** Babcock & Wilcox Co.

At the time of removal the element has accumulated 14,281 hrs of operating service of which 50 per cent had been with steam-outlet temperatures in excess of 1200 F, 31.5 per cent in the temperature range of 1100 to 1200 F and the remainder of the time at temperatures below 1100 F. During the same period (due to customary banked periods at night and week-end outages) the element also had been subjected to 828 temperature cycles of which 332 included temperatures below saturation when the steam was shut off.

Upon removal, the element was returned to the laboratory for a complete metallurgical investigation of the various tube materials and weldments. This investigation has included complete metallographic examinations of the tube materials and weldments, particularly with respect to the extent of external and internal oxidation and microstructural changes, and mechanical testing of tube materials and weldments such as room and elevated temperature (1350 F) tensile and impact tests, hardness determinations, flaring tests and side bend tests of weldments. Records had been made periodically during the test period of any changes in external dimensions of the tubes. Stress-rupture testing of the tube materials and weldments has been initiated, but owing to the long-range nature of these tests, conclusive results are not yet available. This study of the stress-rupture properties will be reported later. Steam-oxidation tests on conventional superheater materials, conducted with cylindrical specimens shrink-fitted on the core rods of the test element at locations of increasing steam temperatures, likewise will be reported at a later date.

The final examination indicated that no serious deterioration of the essential properties has occurred in this pulverized-coal-fired unit. The property most notably affected was impact strength but, with the possible exception of Timken 16-25-6 there appears to be adequate shock resistance remaining for superheater service, particularly at elevated temperatures. Changes in properties were most rapid during the first 6950 hr of service followed by a lower rate of change thereafter. The various weld deposits, particularly Armco 17-14CuMo, had quite low impact resistance after service.

The oxidation resistance of all alloys appears to be adequate for the service for which they were employed. The investigation revealed also that the nonstabilized alloys 304 and 316 suffered no intergranular attack.

The performance of the experimental superheater and the behavior of the alloys of which it was constructed indicate that materials are available for use in superheaters for high pressure steam up to 1250 F.

The ASME Research Committee on High Temperature Steam Generation is concerned with the evaluation of materials as superheater tubing for the temperature range of 1100 to 1500 F. One phase of this project concerns exposing tubes made of 17 different alloys to steam flow at 2000 psi and at various temperatures within the above given range. The project is financed by contributions from users and manufacturers of high-temperature steam generating equipment. The Navy Department's contribution is the design and fabrication of the equipment for exposing the special tubes to steam flow during a test programmed to last three years.

The report, "Evaluation of the Prototype Unit for the ASME High-Temperature Steam Generation Investigation" by **Bela Ronay** and **W. E. Clautice,** U. S. Naval Engineering Experiment Station, and **W. F. Erskine,** ASME Research Committee, presents the test of the prototype portion of the final test equipment. This prototype was built to evaluate the design features of the various components and the reliability of the automatic control devices intended to serve the final installation. This unit was designed and built at the U. S. Naval Engineering Experiment Station, Annapolis, Md. The final installation will contain five such units as the prototype—all operating in series. Fabrication of the entire plant is under way and scheduled for completion in February, 1956.

The third paper in this session, "High Temperature Corrosion of Alloys Exposed in the Superheater of An Oil Fired Boiler" by **D. W. McDowell, Jr., R. J. Raudebauth,** The International Nickel Co., and **W. E. Somers,** Public Service Electric and Gas Co. A program to assist in the determination of which heat-resistant alloys perform most satisfactorily in various high temperature corrosive environments has been conducted for the past several years by the Stainless Steel and Heat Resistant Alloys Section of the Development and Research Division, International Nickel Company, Inc. This information has been accumulated by the installation of heat-resistant test racks containing a wide variety of test specimens in actual industrial environments where information is desired and needed. By testing materials in the actual service environment, much more realistic information is obtained than by conducting similar tests in the laboratory. After a suitable exposure time, the racks are removed from the high temperature environment and each test specimen is sectioned and examined under the microscope to determine the type and extent of attack. For comparative purposes, these results are extrapolated to inches penetration of attack per year for each alloy. Results of such tests materially aid in the selection of materials which are most suitable for a given industrial high temperature environment.

In cooperation with the Public Service Electric and Gas Co., Newark, N. J., a high temperature alloy investigation was instigated by exposing a series of test racks in the superheater of an oil fired boiler using Bunker

"C" fuel oil. The presence of large percentages of sulfur, vanadium, sodium and calcium, in this Bunker "C" oil led to the belief that such an environment would show high deterioration rates for all alloys exposed.

This assumption proved to be true. Nevertheless, the authors' companies felt it important, from the economics point of view, to have a basis for judgment as to how much longer certain alloys would last than others. In other words, the investigation would ascertain whether the exploitation of certain of the studied alloys, in preference to the others, would be justified on the basis of economic considerations and their length of service.

The boiler selected for the installation of the three racks is a Babcock & Wilcox Co. radiant type boiler, designed for a full load steam output of 550,000 lb per hr at 1350 psi, and 950 F at the superheater outlet with either pulverized coal or oil firing. This boiler, No. 52, Marion Generating Station, Jersey City, N. J., went into service in 1941 and had been fired with Bunker "C" oil since April 1952.

All three test racks were supported from a hook clamped to one of the first row tubes of the second bank of the high temperature superheater about 3 ft from boiler side wall in such a manner that they hung clear of the superheater tubes in the cavity on the furnace side of the bank. Because of this method of support, the specimens may be said to have been at the gas temperature.

Wrought alloys, cast alloys and cast alloys with various coatings were tested. Before installation into the test rack all specimens were carefully gaged for thickness with micrometers. After exposure, prepared sections were measured under a micrometer microscope in order to record the thickness of unaffected metal remaining and structural discontinuities in the scale.

The maximum deterioration rates of all of the test specimens were expressed in inches penetration at the surface for the duration of exposure and by linear extrapolation for a year's interval. This extrapolated value makes it possible to compare the corrosion rates. These results were given in tabular form. The data from this table were arranged in order of the severity of the parent metal attack with the material suffering the least attack at the top and the severity of corrosion getting progressively greater down the list. It is interesting to note that the four coated samples had rather a fast corrosion attack on the coating; however, the duration of the test was not long enough to allow complete penetration of the coating. What would happen to the parent metal when and if the coating were penetrated by the attack of the corrosive atmosphere is not known. The reason for putting these coated specimens at the top of the list, the authors explained, were merely to show that there was no base metal attack in this case. It should be pointed out that it was not considered practical to extrapolate the corrosion rates to inches penetration per year for coated specimens. These coated specimens were discussed in greater detail later.

The test rack was positioned vertically, the samples being in a horizontal position, one above the other. The data given in the tables showed a number of the specimens were thinned more along one edge than the other; with maximum attack occuring along the leading edge relative to gas flow. In those cases where a consistent difference in the degree of attack was observed along opposite edges, two penetration rates were given.

Boiler Operation

The paper, "The Work of the Central Electricity Authority (Britain) on the Fouling and Corrosion of Boiler Plant" by **H. E. Crossley,** Central Electricity Authority, covered a period of seven years on problems concerned with the external fouling and wastage of heating surfaces in a boiler plant.

The introduction explained the organization of researches of this kind within the Authority and pointed out that the subject treated in this paper is mainly concerned with full-scale trials on boiler plant. The author then summarized the results of inquiries to learn the extent of boiler-fouling troubles and air-heater corrosion in British power stations. It was felt that a considerable improvement had been attained during the period surveyed. The correlation of boiler fouling with constituents of coals burned, particularly the rate of fouling of superheaters as related to the chlorine content of coal was then taken up. These tests led to a method of alleviating fouling by blending coals as described in the paper. This was continued with a brief account of other methods of alleviating trouble, such as the removal of chlorides from coals; attempts to remove sulfur compounds from coals; the humidification of combustion air; the recirculation of flue gas; the use of acid-resistant metals in air heaters; the use of coke breeze; the raising of minimum metal temperatures in air heaters; the reduction of superheater metal temperatures; modifications of the combustion of oil, and of the combustion of pulverized fuel.

Future investigations for which preparations are now being made were mentioned. The most important of these were thought to be an investigation of the many effects of recirculating flue gas with pulverized-coal combustion, and a fundamental study of metal and gas temperatures and gas composition associated with varying combustion conditions. The paper concluded with a brief discussion in which it is considered that the stage already has been reached where methods of alleviating present-day fouling and corrosion trouble are known. Present trends, therefore, are to assess the relative costs of different methods of alleviation; to attempt to forecast problems of the future, and to work out economic methods by which these problems can be overcome.

F. G. Feeley, Jr., Carbide and Carbon Chemicals Co., discussed his company's attempt to solve its fly-ash disposal problem in the paper "Fly-Ash Refiring." Fortunate indeed is the industry or individual who is able to select the site of a plant with the idea of providing facilities for the disposal of fly ash resulting from the combustion of coal, in Mr. Feeley's opinion. Cooling water and raw materials usually predominate in site selections. Even though fly-ash disposal might be a factor in the selection of a modern plant site, it certainly could not have been envisioned 30 years ago when some of the now vast plants of Carbide and Carbon Chemicals Co. had their beginnings.

The latter situation held certainly true of the author's company's plant on the Kanawha River at South Charleston, W. Va. The first boiler plant consisted of six 20,000-lb-per-hr Sterling boilers—stoker fired. Three boiler plants presently serve the plant, with a

capacity many times the original 120,000-lb per hr. During years of expansion, fly ash has been pumped to first one low-lying area after another until the adjacent topography no longer provides a natural source of disposal. Fly-ash disposal costs have mounted to figures exceeding $1.75 per ton. Future disposal costs will rise even more sharply because of the need of pumping fly ash over adjacent ranges of hills into new low-lying ground.

When the latest power plant expansion came along it was decided to investigate a separate device to burn carbon out of and melt the fly ash from the new as well as existing boilers. Bearing in mind that the fuels native to the area average less than 10 per cent ash, and that coals are being burned elsewhere in the country with ash contents approaching 40 per cent, it was reasoned that a properly designed boiler should be able to refire ash up to a point where the total inert dust loading in the furnace approached that which would prevail with a coal of 40 per cent initial ash content.

Drawing in every way possible upon the experience of other plants, a slagging bottom boiler was developed that was unconventional in that the hearth is of purely refractory construction and completely separate from the structural and pressure parts of the boiler. The boiler is fired by downwardly inclined adjustable burners —three in the front wall, three in the rear wall, and staggered—to promote maximum turbulence with the higher temperature zone in the center of the hearth in a line parallel to the boiler drums. The slag-tap opening is in the near side of the hearth. Dust is collected from a gravity hopper below the last boiler pass, from a mechanical separator after the air heater, and from a vertically oriented electrostatic precipitator following the induced-draft fan. A total of 11 reinjection feeds, utilizing hot air from a separate single-stage blower for motive source, pick up the dust from the hoppers and refire to nozzles located between and below the rear-wall coal burners. Pocket-type, motor-driven dust feeders are located on all connections of the two dust collectors. The boiler shown is rated at 289,000 lb of steam per hr, at 615 psig pressure, 670 F total temperature when supplied with boiler feedwater at 388 F. Design furnace heat release is 15,800 Btu per cu ft per hr and the entire furnace envelope is composed of 3 1/4-in. tubes on 3 3/8-in. centers. Design efficiency of the unit was set at 87.0 but its performance has consistently been at 88.6 when operating at design steam flow. Attention was called to the fact that this boiler was built initially without soot blowers and without any future provision therefore. A single long retractable deslagger was installed ahead of the slag screen but this blower has never been used and has now been removed to storage.

The results achieved with this method of firing and refiring have exceeded all expectations. Total stack discharge at 300,000 lb per hr steam flow is less than 0.5 lb per 1000 lb of flue gas. All ash is recovered as a slag which is readily disposable and sometimes asalable product. The boiler is tapped once a day requiring approximately 7 man-hours of labor. The slag has been used for roads, driveways, and parking lots and is under investigation as a raw material for the fabrication of building blocks, bricks, etc.

A similar, but smaller, boiler at the Chemicals Company's Institute plant, West Virginia also is performing satisfactorily and this unit is consuming, without detrimental effect, the fly ash from an adjacent dry-bottom boiler. At South Charleston plans are under way to refire to the new unit dust from adjacent units.

Installed cost of the entire unit was about $6.76 per lb of design capacity.

Quite apart from achieving the basic objective, the South Charleston boiler and its smaller partner at Institute, have produced an unexpected benefit. Absolutely no slagging or heating surface fouling of any sort has so far occurred above the burners or at any point thereafter. Please note that it was mentioned earlier that the deslagging blower originally installed has been removed. No manual cleaning of the boiler, in service or out of service, has ever been required. The fact that this cleanliness is complete is indicated by the fact that gas temperature entering the slag screen averages 200 F below the manufacturer's expectation. In considering the impact of the above statements, bear in mind that this boiler serves a process which never permits a drop in load except on scheduled semi-annual outages. In addition, because of its demonstrated capabilities, this boiler is consistently operated at loads in the vicinity of 310,000 lb per hr, and the author's company contemplates changing the range of the flow meters to permit its operation in the future at loads approximating 325,000 lb per hr.

The author believed the freedom from slagging and fouling was due to the high inert dust loading in the combustion zone. The adjacent furnace atmosphere of this boiler may possibly be serving as an absorbing medium for the deposition of the vapor-phase products of combustion, such as alkali sulfides, which normally are associated with adherence of fly ash—and subsequently slag—to metallic surfaces. Mr. Feeley felt it essential to the progress of the fuel-burning art to learn more about this phenomenon in the hope that the good features of this design can be extended to other boilers.

"Factors Influencing the Dynamic Behavior of Tall Stacks Under the Action of Wind" by **M. S. Ozker** and **J. O. Smith,** Detroit Edison Co., sets forth what the authors believed to be a new concept of the dynamic response of tall stacks to wind action, in that the wind-induced vibrations of a stack are classified as "self-excited" rather than "forced."

As the authors pointed out the effective dispersion of gaseous industrial wastes requires increasingly high stacks in order to prevent excessive air pollution at ground level. This increasing height introduces problems in the stability of these structures. Certain recent instances of serious difficulties have been experienced with tall power-plant stacks due to wind-excited vibration. It has been known for the past 60 years that wind forces can cause high stacks to oscillate. However, specific information on amplitude, frequency of vibration, structural damping, and the nature of wind-induced exciting forces has been meager.

The direction of this vibration motion on tall stacks is normal to wind direction. The stack structure under wind action constitutes a self-excited vibrational system. The vibration frequency is the natural frequency of the structure and remains constant for all wind velocities. The stack is at resonance at all times. There

is no critical wind velocity in the sense of forced vibrational response. The amplitudes increase with increasing wind velocities.

All other structural features being the same, brick-lined, riveted steel stacks possess more structural damping than gunite-lined welded steel stacks. The structural damping of self-supporting gunite-lined welded steel stacks is predominantly through the foundation. The logarithmic decrement for the latter type is essentially constant for sizable deflections.

The logarithmic decrement for building-supported, brick-lined, riveted steel stacks increases with increasing amplitudes. This is a desirable feature. In conventional stack arrangements steam generators when present underneath the stack appear to serve as vibration absorbers, thereby contributing substantially to the over-all damping capacity.

W. L. Wingert and **R. J. Stanley,** Detroit Edison Co., discussed "Design of a Large Coal-Fired Steam Generator for 200 F Exit Gas Temperature and Operating Experience with Pilot Plant." One of the few remaining sources available for major cycle improvements in a conventional plant cycle, the authors reasoned, is the sensible heat loss in the steam-generator stack gases. Reduction of this loss in coal-fired steam generators is limited for the most part by the amount of sulfur and moisture in the fuel. Conservative design, in general, has been restricted to a minimum full-load stack-gas temperature ranging from 250 to 300 F depending on the quality of fuel economically available. The restriction stems from such operating problems as corrosion, air heater fouling and flue dust removal difficulties.

Based on some exploratory investigations it was decided to review the studies of the series air-preheater design using 200 F full-load stack-gas temperature instead of 235 F. The cooperation of the Air Preheater Corporation was enlisted and with their assistance the studies were carried out. Basic design requirements established for the study were as follows:

(*a*) The upstream or hot-air preheater should operate in a temperature range at all times such as to preclude or minimize fouling and this temperature would be conservative from the standpoint of dust-collector design.

(*b*) The downstream or cold heater should be arranged to permit frequent and convenient removal from service for surface washing, this outage in no way to influence steam generator availability or capacity.

(*c*) Unit operation should be maintained at a reasonable efficiency during cold heater outage periods.

(*d*) Since an installation of this type would be in the nature of a calculated risk the design should lend itself to easy and low-cost revisions to return the unit to a conventional design and efficiency basis.

Results of these studies showed a boiler-efficiency improvement of upwards of 1 $^1/_2$ per cent. Considering all investments and costs for equipment, additional power, etc., the efficiency saving represented a good return on the increased first cost. Considerations other than cost which appeared favorable were, (*a*) such an installation would certainly be a progressive step in improving boiler-plant economy for this and future plants; (*b*) it was believed that continuity of service for a steam generator would be improved by the fact that the hot heater would be operating at a temperature conducive to trouble-free operation and the cold heater could be removed from service without affecting the unit availability and capability, and (*c*) the dust collector would operate at a temperature which would minimize corrosion and dust-removal problems. These factors led to a decision to proceed with the design and installation of the series air-heater arrangement for unit 3 at the River Rouge Plant.

Since relatively little performance data on low gas-temperature operation with coal firing was available it was believed a pilot test plant could give valuable information and load to design features resulting in improved operation of the main unit. To this end The Air Preheater Corporation and The Detroit Edison Company collaborated in the installation and operation of such a test plant at the Conners Creek Plant in Detroit. The test unit, an actual Size 7 air preheater, was put in service in late February 1955. The authors hoped that information gained will lead to the optimum heater design such as basket construction, location of basket removal doors, materials, etc., and will establish optimum operating methods; i.e., type, medium and pressure for soot blowing, service washing procedures and frequency, corrosion protection requirements, etc. Preliminary results of this test were discussed.

Gas Turbines

"Tests of an Experimental Coal Burning Turbine" by **D. L. Mordell** and **R. W. Foster-Pegg,** McGill University, had its origin in 1949, where one of the authors suggested that by the use of the exhaust-heated cycle for a gas-turbine power plant, the new problems and difficulties then besetting those who were trying to produce a coal-burning gas turbine, including (*a*) Feeding of pulverized coal under pressure; (*b*) burning pulverized coal under pressure; (*c*) gasifying coal under pressure; (*d*) separating ash from high-temperature gases; (*e*) establishing the tolerance of turbine blades to ash erosion might be replaced by two problems different in degree but not in nature from those encountered in the design of boilers; namely, (*a*) combustion of coal in a furnace at essentially atmospheric pressure; (*b*) heating of a compressed gas by transfer of heat from hot combustion products. It appeared that adaptation of the existing technology to the gas-turbine conditions should prove easier than the evolution of a completely new technology. It was recognized, however, that the differences in degree made it impossible to design, with confidence, a power plant which might be expected to be immediately successful. It was, therefore, suggested that a purely experimental plant should be designed, constructed and tested, to lay the foundations for a future successful design.

Representatives of the two major Canadian railroads considered that this proposal might lead to the evolution of a coal-burning gas-turbine locomotive that would play a useful part in their operations. The Dominion Coal Board felt that such a program might lead to the development of improved ways of utilizing coal and thereby effectively help the Canadian coal industry. The Department of Mines and Technical Surveys then placed a contract with McGill University for such a program to be carried out under the senior author's direction. Since that time, a vast amount of work has been done.

The experimental plant has been built and has now completed its first series of tests. A great deal of theoretical design and economic consideration has been given to possible applications. The present paper reviews what has been done, and discussed the lessons that have been learned and their application in the future.

It is perhaps a little early to make definite conclusions but this first test series has firmly established that the exhaust-heated cycle is a perfectly feasible mode of operation for a coal-burning gas turbine. It has furthermore been demonstrated that it is a particularly rugged machine, capable of operating under conditions of considerable maladjustment and deterioration of components.

Before it could be claimed to be practical, in a commercial sense, as distinct from technically practicable, it remains to be shown that the problems encountered can be resolved and that the heat is not too expensive. As a result of the work already done, no fear is held that the difficulties cannot be solved, and it is hoped that the next test series, due to commence in October 1955, will show a large step forward and at the end of which manufacture of an industrial plant giving every hope of successful commercial performance could be considered. It must be remembered that the problems are essentially those which the boiler makers have already solved. As to the cost factor, studies show that the heater cost is far from prohibitive in applications requiring relatively small powers; i.e., less than say 5000–7500 kw.

Despite the predictions of 20 years ago, the industrial gas turbine has not yet dethroned the piston motor, because it still burns too much fuel. Without regeneration, thermal efficiency of the industrial gas turbine is about 20 per cent, or half the diesel's 40 per cent. A regenerator may improve efficiency to 30 per cent, but this at the price of a much heavier and more voluminous installation. Something else must be found to bring thermal efficiency up to 30 per cent, without resorting to bulky heat exchangers. Has the combustion chamber received as much attention as the other components of the machine, the compressor, for instance? This was the challenging introduction employed in the paper "Pulsating, Pressure Generating Combustion Systems for Gas Turbines" by **F. H. Reynst,** Sevres, France.

In today's gas turbines the highest pressure must be built up mechanically, by means of a turbine-driven compressor. This results in low work ratio (percentage of turbine power available as net output) and high internal loss. In the piston engine, on the other hand, pressure is increased automatically by constant-volume combustion. This is an important reason for good thermal efficiency. Another reason is high gas temperature at the beginning of the expansion, no cooling of combustion products by excess air being required. Constant-volume combustion and absence of excess air are the outstanding advantages of the piston engine, of which the principal defects are heat loss to the cooled cylinders, and incomplete expansion. A nice characteristic of the piston engine is also absence of flow work. Compression with flow work (case of the gas turbine) required 1.4 times the power as compression without it.

Suppose the ordinary constant-pressure combustion chamber of a gas turbine is replaced by a Lenoir engine, working as a pressure generator. The improved Lenoir engine, burning a stoichiometric mixture and driving an excess air compressor, has a pressure ratio of nearly 2.0 and improves thermal efficiency 27.3 to 44.5 per cent.

After establishing this interesting premise Mr. Reynst proceeded to calculate the thermal efficiency of two gas turbines for ideal constant-volume combustion and found for a "high-grade" plant 40 per cent at compressor pressure ratio 5 and for a "low-cost" installation 33 per cent at compressor pressure ratio 2.5. Generator efficiency in both cases was about 17.5 per cent.

Then by assuming a 10 per cent generator efficiency for practical pressure-generating combustion chambers, Mr. Reynst established a thermal efficiency of 33.1 per cent for "high grade" and 24.7 per cent for "low cost" gas turbines. Generator efficiency of 10 per cent corresponds with generator pressure ratio of about 1.6.

Pulsejet engines of V-I design, Mr. Reynst pointed out, may have 15 per cent thermal efficiency at the air temperature prevailing in gas turbines. A 67 per cent converter efficiency is needed to arrive at 10 per cent generator efficiency. The big problem today is how to build converters. Rotating pulsejet engines in a "fire wheel" cannot be the answer, because of centrifugal forces. The author described the pot-with-diffusor combustion which burns the mixture within a whirl and suggests it may hold the answer to pulsating pressure-generating combustion, which Mr. Reynst believed, may bring the true aerodynamic heat engine.

The paper, "Seal Leakage in the Rotary Regenerator and Its Effect on Rotary-Regenerator Design for Gas Turbines" by **D. B. Harper,** Aluminum Co. of Canada was an analysis of rotary-regenerator seal leakage which was conducted to predict the leakage quantity and the variations of pressure gradient under the sealing shoe. The verifying results obtained from tests of a simulated sealing arrangement are also given. The optimum efficiency conditions of the gas-turbine cycle including leakage and pressure loss are studied; and a sample regenerator design for a specific gas-turbine plant is carried as far as the presentation of design-point curves for sizing the rotary regenerator. A method of reducing leakage is presented and the results of experimental verification are shown. Conclusions are drawn regarding the best general configuration of the rotary generator with respect to the leakage problem.

"Transient Temperature and Thermal Stress in Locomotive Gas Turbine Buckets" by **Mrs. F. F. Buckland** and **J. B. Gatzmeyer,** General Electric Co. was based upon an inspection of the first-stage buckets of a locomotive gas turbine which had revealed that a majority of these buckets had cracks in the leading edge apparently caused by thermal fatigue. To substantiate this conclusion a theoretical investigation of the temperature distribution and resulting distribution during the operating cycle transients was made.

The method of calculating the temperature and stress distribution was described. It related the actual operating experience to the calculations, pointed out the influence of proper engine control in limiting the conditions causing thermal stress, and discussed the use of calculated stresses in predicting the operating life from existing data on the material properties.

The paper "Effect of Turbine Blade Cooling on Efficiency of a Simple Gas Turbine Power Plant" by **W. M. Rohsenow,** Massachusetts Institute of Technology, covered an investigation of the effects of blade cooling on the thermodynamic performance of a simple gas turbine plant.

The efficiency of a simple gas-turbine cycle can be increased by designing it to operate at higher turbine-inlet temperatures. In order to operate these turbines at higher temperatures it is necessary to cool the blades and possibly the casing and rotors in the earlier stages until the gases are reduced to a value between 1000 and 1500 F depending on the kind of metal employed. Various methods of cooling turbine blades have been investigated by the NACA and published in various unclassified technical reports since 1947. A survey of some of this work was presented by Ellerbrock at the Heat Transfer Conference in London, England in 1951.

M. A. Mayers, A. Matiuk, S. Baron, Burns & Roe, Inc., in their paper "Combination Gas Turbine and Steam Turbine Cycles" discussed the development of two highly efficient coal-fired combination gas and steam turbine power plant cycles and the effects of a number of cycle variables on the plant efficiencies. Some of the engineering problems of these cycles were discussed. Investment cost estimates and evaluations were presented showing the annual production savings attainable with the combination cycles.

The principal advantage of these combustion cycles is a significant improvement in plant heat rates, which are about 6 per cent better than present day high efficiency reheat plants. Another advantage that should not be lost sight of is the requirement in some combination cycles of a high degree of cleaning of the boiler flue gas. Thus, the stack gas discharged to the atmosphere is substantially dust-free. In view of current activity in the control of air pollution, such cleaned stack gas will ultimately be an essential characteristic of steam power plants. Obtaining it without increase in the essential cost of certain of the combination cycle plants is an undoubted advantage.

Recent advances in mechanical engineering practice bring combination cycle plants into the realm of present practicability. The gas turbine is now a reliable prime mover. Another major factor is the growing experience of American Boiler manufacturers in the design and construction of pressure-tight boilers, which are required in some of the combination cycles. Special requirements of the United States Navy, as well as the increased use of pressure firing in stationary plants, have contributed to this development.

For a conventional plant to secure improvements of the order of 6 per cent in plant heat rates, would require equipment designed for supercritical steam pressures, temperatures of steam above 1050 F and multiple steam reheating. From the stand-point of air pollution, the possibility of producing a substantially dust-free stack gas coupled to a reduction in annual production cost is a very promising development for the supercharged combination cycle. These factors of fuel economy, reduced investment cost and reduced dust nuisance show that the supercharged combination cycle should be given further serious consideration by all groups in the power industry. There appeared to be no doubt in the authors' minds that this cycle will become an accepted means of power generation in the near future since its promise looms so large on the horizon.

The exhaust gas combination cycle, although not as thermally efficient as the supercharged steam regenerator cycle permits substantial gains over the conventional cycle and can be designed and built at the present time using already-developed and proved equipment.

The authors urged that the power industry vigorously pursue the development of the types of combination cycles discussed in this paper. New concepts of power generation are becoming increasingly necessary to cope with rising costs. These combination cycles are significant because of the opportunity they present to meet the problem of higher costs.

Turbine Supervision and Testing

There were several papers presented on the general subject of turbine testing. Space permits only the following abstract.

In a paper entitled "Turbine Supervisory Instruments" by **J. C. Spahr** and **R. L. Richards** of the Steam Turbine Division of Westinghouse Electric Corp., the operation and function of a series of current turbine supervisory instruments were described. The instruments are shaft-eccentricity meter, cylinder-expansion meter, differential-expansion meter, flange differential-temperature meter, shaft-position meter with a hydraulic back-up device, thrust meter, and shaft-vibration meter.

These supervisory instruments are used to supplement the operator. All of them can be equipped with an alarm circuit having limit contacts. These are set for values beyond which continued operation is considered unsafe. Thus, if any of the above measured functions exceed safe limits, an alarm is sounded to warn the operator of the existing condition. It is the duty of the operator to investigate the condition and determine what action should be taken. Used in this manner, the supervisory instruments serve as a back-up and guide to the operator. The decisions of operation are left to the operator.

Recently the philosophy has been advanced that the supervisory instruments should be the primary source of turbine-operation decisions; that they be used in the actual operation of the turbine rather than to just give the warning signal. The instruments would be equipped with automatic devices to trip the turbine off the line in the event the measured function exceeded safe limits.

The reasoning responsible for this trend is that the supervisory instruments are in a better position to "observe" the conditions of the unit, and that the instruments are in reality recording the results of internal disturbances within the unit. The operator must depend on the instruments to warn him of abnormal developments; therefore, the instruments could easily complete the entire function of operating the unit. Such an approach to instrumentation means that the present supervisory instruments must be converted to mechanical operators. It is expected that the trend toward operation by instruments will be a gradual one. The authors stated that Westinghouse has started in the direction that the supervisory instruments will be arranged to trip the units off the line in the event the instruments indicate a condition of distress.

Power Practices in 1955

FOLLOWING the trend of the times power developments over the past year have gone beyond the previous record breaking levels of a year ago in all reportable areas such as: (1) the highest 12-month (October 1954 to September 1955) electric energy production ever established by the public utilities—nearly 525 billion kwhr—better than 1.3 per cent over the previous maximum set during the 12-month period ending a month earlier and 13.9 per cent above the roughly 461 billion kwhr figure for the same October to September period of a year ago, (2) a combined utility and industrial energy production that reached 12.9 per cent above that of the same 12-month span in 1954 to about 602 billion kwhr, (3) a utility and industrial generating capacity that aggregated 126,946,009 kw on September 30, 1955. All the foregoing are based on the latest available Federal Power Commission reports. This same source further puts installed capacity of utility generating plants at 110,909,719 kw on September 30, 1955, as against 99,156,324 kw reported in service on September 30, 1954. Industrial generating capacity, according to the FPC, dropped off slightly from the 16,304,816-kw level as of August 30, 1954, to 16,036,290 kw on September 30, 1955. This industrial capacity includes the stationary plants of electric railroads and railways.

Capacity Additions

Manufacture of heavy electric power equipment continues at a relatively high rate according to the Eighteenth Semi-Annual Electric Power Survey of the Edison Electric Institute. Scheduled production for 1955, however, is below the record new production of recent years. This Survey indicates that the total capacity of new generating units placed in commercial operation during 1955 will be about 13,000,000 kw. As of October 1, 1955, the capacity of new generating equipment placed on order by U. S. electric power systems totaled more than 15,000,000 kw. Including the year 1955 the program of expansion which extends to 1959 or beyond comprises 501 new generating units totaling over 41,000,000 kw.

For the 76 units supplying the roughly 8,125,000 kw recorded as put into service during the first nine months of 1955 (as of October 1, 1955) the nation's electric power systems had added steam generating capacity in the amount of 33,400,000 lb per hr. This compares with 1954's figures for the same period of 90 units supplying 7,676,800 kw and for which the electric power systems added 61,785,000 lb per hr of steaming capacity. In both cases the steam generating units are reported for those installations employing pressures of 450 psi and higher.

Capability of the electric power systems is estimated to reach over 115,000,000 kw by the end of 1955, an increase of about 11 per cent for the year. The scheduled capability at the end of 1958 will exceed 141,000,000 kw, which the EEI Survey points out, is an increase of more than 36 per cent over the actual capability at the end of 1954.

Thermal power projects in the EEI compilation constitute 85 per cent of the scheduled generating capacity expansion and the remaining 15 per cent is hydro. Two of the thermal projects, totalling 250,000 kw, will use atomic fuels.

The average size of steam generator purchased for the 73 units reported sold for the twelve-month period ending April 30, 1955, was 843,000 lb per hr with a drum pressure of 1920 psig and a throttle temperature of 995 F. There were 47 of these units employing reheat including one for double reheat. The average throttle temperature for these reheat designs was 1025 F and the reheat temperature 1010 F. The double reheat installation employed 1050 F for its temperatures. Twenty-four of the 73 units were pressure-fired.

Individual Systems Growths

The seven-state American Gas and Electric System reports it is presently engaged in the biggest expansion program in its 50-year history and there is every indication that there will be no let-up in the rate of this expansion in the foreseeable future.

Currently under construction are four units totaling 795,000 kw: two 225,000-kw units at Muskingum, to be completed in 1956 and 1957, respectively; one 225,000-kw unit at Appalachian's Glen Lyn (Va.) Plant, to be finished in 1956, and one 120,000-kw unit at Ohio Power's Philo (Ohio) Plant, also scheduled for 1956. The last-named unit is the developmental one utilizing a steam pressure of 4500 psi. Completion of these units will raise AGE System total capability to 4,800,000 kw by mid-1957.

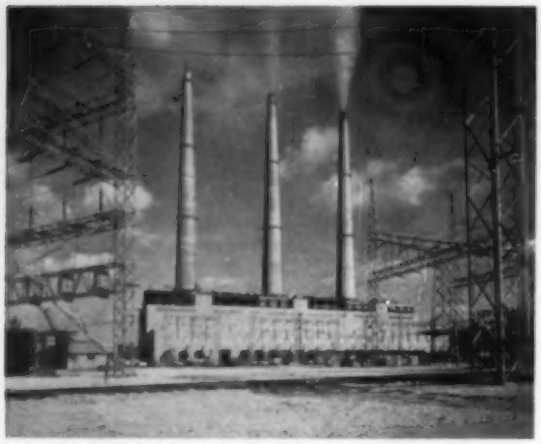
Detroit Edison Co.'s River Rouge Plant alone will house 820,000 kw of new capacity with 520,000 kw of it scheduled for 1956 and the balance, a single installation, for 1957. This last named unit, a 300,000-kw turbine generator, required at the time of its purchase a 2,000,000 lb per hr steam generator, then the world's largest. Since that time the Commonwealth Edison Co. has ordered for its Waukegan, Ill., Station a 2,100,000 lb per hr boiler and the Consolidated Edison Co. of New York has purchased a 2,400,000 lb per hr unit for their Astoria, L. I., plant.

As expected last year the TVA added heavily to its production capacity in 1955. Of the 2,900,000 kw predicted 2,100,000 kw was on the lines as of October 1, 1955.

The Ohio Valley Electric Corporation announced December 27, 1955 that the fifth and last of Kyger Creek's 215,000-kw steam turbine-generators had been placed in operation. At 1,075,000 kw this station is the second largest power plant ever built anywhere by private enterprise.

Kyger Creek and Clifty Creek Plant, its sister station located at Madison, Ind., also on the Ohio River, were built by OVEC for the single purpose of supplying the electric power requirements of the U. S. Atomic Energy Commission's giant new Portsmouth (Ohio) Project. Five 215,000-kw units also are in operation today at Clifty Creek. Operation of the sixth and final unit there is scheduled for February 1956 and will give Clifty Creek a total of 1,290,000 kw capacity, making it the world's largest private power plant. This means that OVEC will have placed 2,365,000 kw of electric power capacity in operation in 12 months' time.

Outstanding New



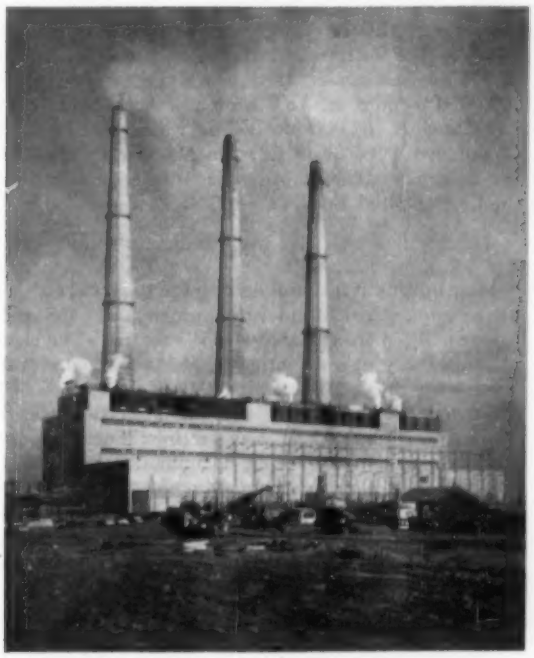
CLIFTY CREEK STATION, Indiana-Kentucky Electric Corporation, subsidiary of the Ohio Valley Electric Corporation, represents the largest single power plant ever built by private enterprise with six 215,000-kw generating units when it is completed by February 1956

ROCK RIVER STATION, Wisconsin Power & Light Co., started up in 1955, employs cyclone furnace firing on a 525,000 lb per hr, 1675 psi, 1005 F, 1000 F reheat steam generator

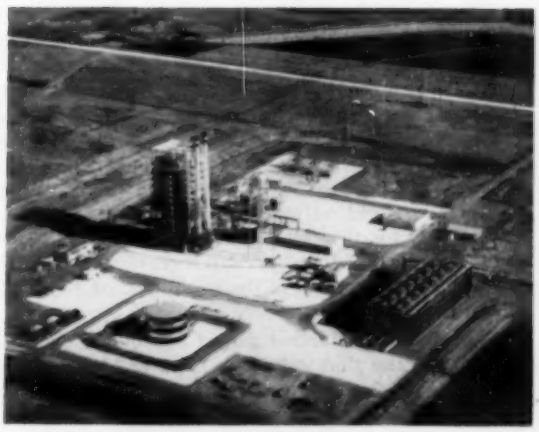
VERMILION POWER STATION, Illinois Power Co., joined the Company's system in May 1955 with a reheat boiler capable of supplying 525,000 lb per hr of steam at 1500 psig, 1000 F and 1000 F reheat

Plants of 1955

MILLIKEN STATION, New York State Electric and Gas Corp., came into being in October 1955 to serve a 135,000-kw turbine generator and is the first of a proposed five-unit plant. Steam is generated at 1800 psig, 1005 F reheated to 1005 F



KYGER CREEK PLANT, owned and operated by the Ohio Valley Electric Corp., constitutes the second largest power plant built by private enterprise with five 215,000-kw generating units



COLLIN STEAM ELECTRIC STATION, Texas Power & Light Co., employs an outdoor type, reheat boiler to give steam to its 110,000-kw turbine generator. Steam is delivered at 1500 psig, 1005 F, reheated to 1005 F

Electric Energy, Inc., another specially formed electric generating company to supply the Atomic Energy Commission's needs, brought in 302,500 kw of new capacity as of October 1, 1955, at its Joppa plant.

Nuclear Power

The Atomic Industrial Forum, Inc., reported that the year 1955 marked the year that U. S. industry got into reactor building in a big way. Research and test reactors were approaching the even dozen mark. The military's needs, including the Army's package power prototype and the Navy's various submarine and ship propulsion reactors, were approaching the same level of about one dozen.

The purely power reactor units for electric generation on the books or building number the original 60,000-kw pressurized water Shippingport, Pa., Duquesne Light Co. installation, a 150,000-kw, homogeneous design for the Pennsylvania Power & Light Co., an 11,500-kw pressurized water unit for the Syndicat d'Etude de l'Energie Nucleaire, Brussels, Belgium, a 75,000-kw, sodium graphite type for the Consumers Public Power District, a 20,000-kw, sodium graphite prototype for the AEC, a 100,000-kw unit for the Atomic Power Development Associates, a 180,000-kw boiling water reactor for the Commonwealth Edison Co. and Nuclear Power Group, Inc., and a 140,000-kw pressurized water installation for the Consolidated Edison Co. of N. Y.

Fuels

Mine output of bituminous coal for 1955 was estimated by Keystone Coal Manual to approximately 468 million tons, up 18.7 per cent above 1954's figure. The electric utilities, last year's sole bright spot for the coal industry, now share the spotlight with the steel interests. The utilities in 1955 consumed 138 million tons or better than 20 per cent above last year's 115 million high. The steel industry jumped from 84 million tons in 1954 to 115 million in 1955, a 37 per cent increase. In the power generation field the TVA plants alone used 14.8 million tons and the atomic energy project suppliers required 20.6 million tons. Apparently the coal industry has successfully come out of its doldrums of 1954.

The fuel oil industry, according to a year-end report by the American Petroleum Institute, showed that the total demand for residual fuel oil exceeded the production by a considerable margin. Something like 551 million barrels of residual was sought and 418 million barrels produced. This demand for 1955 compares with a 524 million demand in 1954 and a 565 million demand in 1953. In keeping, though, with the pattern of recent years the yield of residual fuel oil continues in the decline.

Production of crude oil, however, went on to a record high with 5 billion, 520 million barrels, of which the U. S. supplied 44.7 per cent. For the third straight year the rest of the world outproduced this country. In fact the increase for the rest of the world for 1955 is more than twice that of the American increase or 376 million barrels gain for the rest of the world against 153 million from U. S. A. wells.

Natural gas production gained 875 billion cubic feet in 1955 to raise that industry's total to 11 trillion, 860 billion cubic feet, gross. But gas well completions dropped from last year's record high of 3974 to 3600, or down 9.4 per cent In the opinion of the American Petroleum Institute president, Frank M. Porter, this could be a harbinger of things to come.

The natural gas industry, however, is well aware of the implications these statistics present. According to the report of the director of the Institute of Gas Technology, E. S. Pettyjohn, research is under way at the Institute to find ways and means of meeting the decline in natural gas supplies when it occurs.

Equipment Development

The step into the supercritical pressure range for boiler operation needed, of course, a companion step by the turbine generator manufacturers. This step has been made and the turbine people feel confident that they can keep stride with boiler design advances. Early in the year in a paper before the AIEE, a report was given on an investigation of the economic size for steam-electric generating units. Out of this study came an estimate that within ten years generating units of 500 to 600 mw will be economical.

The paper presented by Professor Baumeister, Columbia University, before the Philadelphia sections of the ASME and the ASCE, December 6, 1954, on "What's Ahead in Power" singled out the temperature barrier as the major block to (1) further developments in the steam power field (2) the perfection of the gas turbine to furnish useful life periods (3) the complete realization of nuclear energy potential with its fission temperatures of 10^6 degrees and fusion temperatures of 10^7 degrees. In his opinion "we have no alternative but to find materials and designs which will enable us to reach into the higher temperature ranges."

Within the areas of refinement of design and manufacturing techniques for the conventional boiler considerable forward strides are being made. Panel construction of furnace walls, for example, offers many economies in field erection time as well as in shop inspection and preassembly. The separated furnace design for the very large capacity reheat boilers has come into its own. This design approach offers material savings in lower overall heights and hence in supporting steel members as well. Field experience brings out the additional advantage of spreading out the boiler furnace over a larger area to where more construction help can work side by side during the erection phase.

Gas Turbines

The gas turbine in the power generation field has maintained its strong appeal of recent years. At the moment the gas turbine seems well established in the range of 1000 hp to 20,000 hp. As such it has enjoyed some limited acceptance in the power field as an aid in meeting peaks particularly in gas rich areas.

For the large-scale power plant there seems two outstanding possibilities for gas turbine application. Both involve combination gas turbine and steam turbine applications. The recently concluded ASME Annual Meeting included a paper on these applications wherein a "supercharged boiler-gas turbine combination" was said to promise a 6 per cent improvement in cycle efficiency over the conventional steam design and an "exhaust heated combination gas-turbine boiler cycle" showed a theoretical 3 per cent improvement.

Quick Pick-up Ability

By THOMAS K HUBER*

The Detroit Edison Co.

The spreading use of initial pressure regulators has produced a reawakened interest in the subjects of spinning reserve and load pick-up abilities. Here is a report on one major utility's investigations of the problem.

DETROIT Edison Co. has always maintained the policy of operating its system with enough running reserve to meet instantly the largest single forced outage on its system. When the River Rouge Plant's Unit No. 3 goes into service this largest single forced outage will be 300 mw.

Until very recently the Company's largest single forced outage was 150 mw represented by loss of a St. Clair Plant unit. As the unit sizes increased and the trend seemed to point to still larger units, a series of special tests were run on the Detroit Edison system to determine the pick-up abilities of the individual plants. As a result of these tests and some relatively recent successful experiences with sudden interruptions of large purchases from their Ontario Hydro Electric Power Commission interconnections there seems to be no need for concern over a forced outage of as high as 300 mw. Fig. 1 pictures an example of quick pick-up ability when a large interconnection flow was interrupted.

Forced Outage Problems

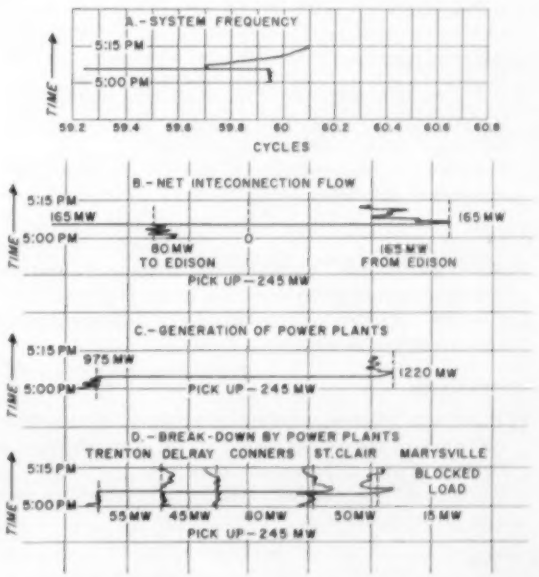
Certainly one of the most difficult times to handle a large forced outage is during a low system load period such as the early morning hours of a Sunday. This, essentially, is what transpires when a large load is thrown onto a plant that has been carrying a low load. The frequency drops, the turbine governors respond to this drop and the turbine admission valves open wide to increase steam flow to the turbine. In a few seconds after this sequence the boiler pressure falls off, and the boiler water level begins to rise. If the pressure drops far enough, in a minute or two, water from the boiler may be carried over to the turbine and in passing through it damage the turbine buckets.

Actually, though, the turbine's initial pressure regulators act to prevent this danger of water carryover. On the Detroit Edison system they are set to permit a 10 per cent throttle pressure drop before throwing the unit off the line. Should such an emergency occur, however, it would make the load pick-up even more of a burden on the remaining turbines carrying the system load. But such an unusually large pressure drop of the magnitude of 10 per cent could normally occur only if a generation area with a few turbines were to become separated from the rest of the system. It could occur, however, if the system were called upon to pick up a load much larger than 300 mw, or on certain turbines if their governors failed to respond properly.

It is possible, then, in a separated area with only a few turbines to experience the loss of a turbine or a series of turbines in the event of a large forced outage on the system. Therefore successful pick-up of actual load demanded in case of a large forced outage accompanied by an area separation requires that the load be limited to an amount that the system plants can meet with an instant response without lowering the steam pressure to the point of unloading. Just how much of a load pick-up ability and the response the individual plants in the Detroit Edison system possessed was the basis for a series of demonstration tests, Table I, following page.

Testing Pick-up Ability

Each plant in the system was tested last spring under its most difficult condition as far as load pick-up ability is concerned, namely, at the lowest load the plant normally



A—Shows frequency restoration after the interruption. B—Is the net interconnection flow for our five major interconnections for the period of the interruption. C—Shows the generation of our five power plants before and after the interruption and the quick pick-up made by the plants. D—Is the pick-up made by the individual plants. It is not to be compared with the table in this article for the load level was higher than the 570 MW of the table.

Fig. 1—This is an example of "Quick Pick-Up." It occured Sunday evening December 5, 1954 when a large interconnection flow was interrupted and portrays plant reactions

* Assistant Load Scheduling Engineer.

TABLE I—DEMONSTRATED PLANT QUICK PICK-UP

Name of Plant	Load, mw	TG's running hp		lp	Boilers hp		lp	Quick Reserve, mw	Date Tested
Trenton Channel	120	2	..	1	3	..	1	70*	9-19-54
Delray	80	2	..	1	3	..	1	40	9-19-54
Conners Creek	150	2	..	1-60	3	..	2	60	4-10-54
St. Clair	150	..	2	..	..	2	..	75	5-5 -54
Marysville	70	2	..	0	2	..	0	30	9-19-54
	570							275	

* Based on 5 per cent drop of steam pressure on load pick-up in 30 to 75 seconds. Pressure unloaders set at 10 per cent drop of steam pressure. Actual pick-up 90 mw when frequency went to 59 cycles and steam pressure dropped 7.6 per cent.

Three of the plants, Trenton Channel, Delray and Marysville, have been revised slightly according to instant pickups during a system disturbance of September 19.

carries. The amount of load imposed for pick-up was set at the quantity that would drop the steam pressure to 5 per cent less than normal. This is only halfway to the automatic unloading point. The time it took to do this varied from 20 seconds to one minute. In future tests, with the experience these first runs gave, this time will be shortened and will be based on the safe rise of water level in the boilers. Table I shows the initial test results. They reveal that the Detroit Edison system has a quick pick-up capacity of 275 mw when the five plants are at the low load of 570 mw. This capacity is possible with a drop in steam pressure of only 5 per cent. This somewhat arbitrary setting of the load imposed on the plant was recognized as very conservative but for first tests it was held to be a reasonable stand to take.

It was felt originally that a liberal margin of safety was needed to take care of errors in the determination of this quick pick-up capacity as well as to take care of improper distribution of pick-up.

The equipment running during the quick pick-up tests was as follows:

Trenton Channel

H.P.—Two 100-mw, tandem-compound, double-flow turbine-generators and three steam generators of a battery of four. Automatic controls.

L.P.—One 50-mw, single-barrel turbine-generator and one steam generator.

Delray

H.P.—Two 75-mw, single-barrel, turbine-generators and three steam generators of a battery of seven.

L.P.—One 50-mw, single-barrel, turbine-generator and one steam generator.

Conners Creek

H.P.—Two 100-mw, tandem-compound, double-flow turbine-generators and three steam generators of a battery of four. Automatic controls.

L.P.—One 60-mw, single-barrel, turbine generator and one steam generator.

St. Clair

Two 125-mw cross-compound with a tandem-compound, double-flow, low-pressure turbine. They have unit reheat cycles. Automatic control. Two additional units have been completed since the test date.

Marysville

H.P.—Two 75-mw, single-barrel, turbine-generators and two steam generators of a battery of four. Automatic controls.

L.P.—Shut down.

At the time of this publication Detroit Edison Co. is in the process of running a second series of quick pick-up tests. In these tests evidence of carryover by conductivity readings at the superheater inlet and maximum drum water level as set by the manufacturers of our boilers is being used as the end point of the quick pick-up instead of the 5 per cent steam pressure drop used in the first series of test. By these tests it is planned to determine the maximum quick pick-up that can be made from the low load and also a percentage pressure drop allowable for setting of the turbines' initial pressure regulators.

Pick-up Capacity Fundamentals

There are a number of factors that influence quick pick-up capacity and include such points as the response characteristics of the fans and the automatic controls and similar auxiliaries, as well as the inherent storage features of the boiler system. When reduced to its fundamentals the quick pick-up capacity of a steam plant, until operating conditions can be changed, comes largely from the flashing into steam of water already present within the steaming boilers. The critical period is when the steam is initially drawn from the boiler without replacement heat. Consequently the point to which pressure will fall is determined by a balance between the delay the storage capacity affords and the promptness of the measures to increase heat input to the boiler.

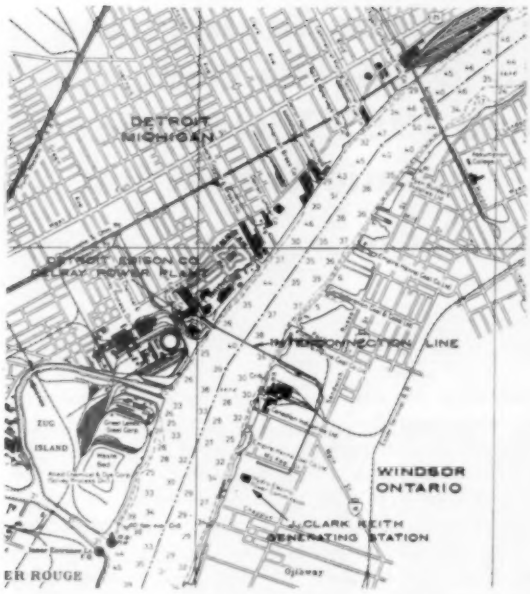
As a result of the desire to achieve a reasonable balance in regards to a plant's pick-up capacity, the broader aspects of light load operation with best economy require a consideration of these points: (1) the safe minimum loading of the steam plants to provide a sufficient and well-distributed spinning reserve; (2) the restriction of the governor action in the case of turbines on the line not full-backed by boiler capacity.

Immediate Applications

This restricted governor action prevents exceeding the boiler capacity with resultant low pressure in case of a sudden frequency drop. Such a safeguard makes sense inasmuch as there is no advantage in carrying a turbine wide open for the first few moments of load pick-up only to have the turbine unload because of low pressure immediately afterward.

The above studies and the thinking behind them were applied at the time The Detroit Edison Co. had completed its two interconnections, Figs. 2 and 3, with the Ontario Hydroelectric Power Commission. Plans were under study by the spring of 1954 to take large amounts of off-peak power from the Hydro system during light load periods on the Detroit Edison lines when large forced outages would be difficult to handle. During these off-peak hours there was low cost surplus hydro power available in quantities up to 250 mw. Such an exchange of power is not without some possible problems such as sudden interruptions produced by transmission line difficulties.

If, for example, The Detroit Edison Co. elected to



Figs. 2, 3—Detroit Edison Co. recently completed two interconnections with the Ontario Hydroelectric Power Commission permitting exchanges of power between the predominantly hydro system of the Canadian organization and the steam system of Detroit Edison with economies for both parties but pick-up capacity limits amount of exchange

take the full 250 mw available during their lowest system load hours as of spring 1954, it would represent 40 per cent, or more, of their total load. A forced outage of this magnitude would be difficult to meet. In addition, as part of the interchange contract, the Detroit plants would have to pick up the load in southwestern Ontario, which is seldom less than 150 mw. The combination, it was felt, would represent too much of a burden for the plants to meet. Consequently the amount of hydro power The Detroit Edison Co. purchases from the Ontario Hydroelectric Power Commission is limited during the lowest load hours by the quick pick-up capacity indicated by the data in Table I.

Future Steps

The details of this whole subject, which has assumed recent importance because of the spreading use of initial pressure regulators, were covered a number of years back.[1,2] A number of observations were made at that time and time has proved them out. Detroit Edison's investigations have re-emphasized (1) the value of low minumum loading designed into equipment so that spinning reserve on the line can be as large as possible, (2) the importance of automatic control equipment having a high speed response in picking up load. Lastly, the Detroit studies indicate an opportunity for improvement in the initial pressure regulator's operating conditions and in its unloading timing.

[1] Article by V. F. Estcourt, *ASME Transactions*, 1937, Vol. 59, pp. 7-20, with discussion on p. 645.
[2] Article by F. G. Philo, *General Electric Review*, 1939, Vol. 42, pp. 520-524.

Progress in Electric Power Generation

J. B. McClure and **A. G. Mellor,** General Electric Co. pointed out in their recent paper before the ASME that in the 73 years since the electric utility industry began with the starting of Edison's Pearl Street Station in New York City on September 4, 1882, the generation and utilization of electric power has become one of the most important factors in our continuing expanding economy. There has never been a serious shortage of power in this country and today the cost of power to the ultimate consumer, in spite of inflation, is at practically the lowest level in history.

It seems certain that the major source of power for some time in the future will be fossil fueled steam-electric generating stations. The present trend to larger single generating units can be expected to continue.

Two plants are now under way that are designed to operate at supercritical steam pressures and using a double reheat cycle. Already consideration is being given to steam pressures of the order of 6000 to 7000 psig. If these first two supercritical pressure plants are successful it can be expected that in the future many of the largest generating units will employ steam conditions well advanced over those in use today, providing they can be economically justified.

In the boiler field, designs of once-through boilers are well along not only for supercritical pressures but also for more conventional pressures. Extension of these designs, together with the use of multiple furnaces should provide the very large, very high-pressure boilers required for the future.

Cleveland Terminal Tower sets stage for Congress

Nuclear Engineering and Science Congress and 1955 International Atomic Exposition

Cleveland, Ohio, December 10–16, 1955

The spacious facilities of the Cleveland Public Auditorium became of nuclear capital of the world for a week in mid-December. Nearly 300 technical papers were presented at the Nuclear Engineering and Science Congress which was coordinated by Engineers Joint Council on behalf of 26 engineering and scientific groups. The 1955 International Atomic Exposition occupied approximately 80,000 sq ft of floor space and presented exhibits from 140 companies, research organizations, educational institutions and government agencies. Sponsored by The American Institute of Chemical Engineers, the highly successful exposition was under management of International Exposition, Athel F. Denham, director. Excerpts from some of the important technical papers of interest to engineers in the power generation field appear on the following pages in the first section of a two-part report on the Congress.

G-E 75,000-watt lamp illumines Cleveland Public Auditorium

Diamond Power Specialty Corp. demonstrates wired television

Exhibit of Westinghouse Electric Corp. features atomic "firsts"

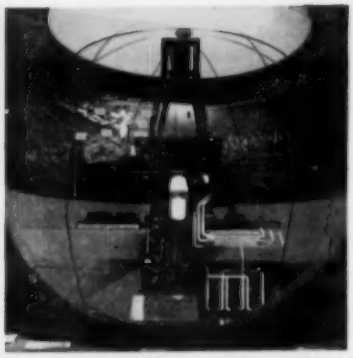
British Board of Trade shows variety of nuclear instruments

Scale model of nuclear power plant by Atomics International

Combustion Engineering illustrates its role in nuclear power

Model of nuclear steam generator shown by Griscom-Russell Co.

High vacuum equipment exhibited by National Research Corp.



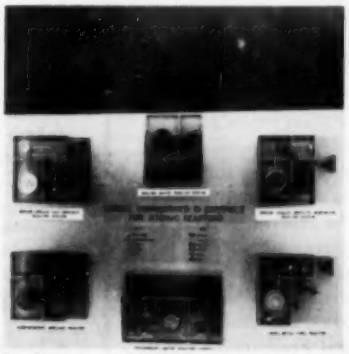
Dual-cycle boiling reactor, one of many elaborate G-E exhibits

Reactor simulator prominent in Bendix Aviation Corp. exhibit

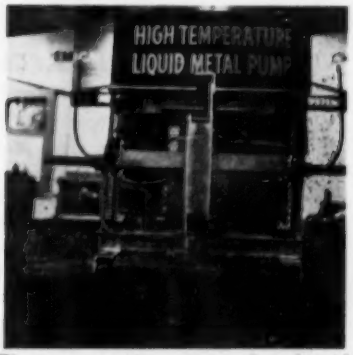
Swiss firm of Escher Wyss. Ltd. shows nuclear gas turbine cycle

Methods of steam generation in nuclear plant shown by B. & W.

Foster Wheeler illustrates homogeneous power reactor



Application of instruments and controls featured by Bailey Meter



Electromagnetic pump for liquid metals in Callery Chemical exhibit

Variety of fuel elements featured by Sylvania Electric Products, Inc.

Cleveland Electric Illuminating Co. exhibits APDA reactor model

Principles of nuclear plants explained in Walter Kidde booth

40 PAGES of helpful information

on Recovering Dusts, Fly Ash, Mists, Fumes and other Suspensions from Gases.

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- Principal elements in a Cottrell unit.
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- Various types of Collecting Electrodes (rod curtains, corrugated plates, pocket electrodes, etc.).
- Typical ways of removing collected material.
- Various Shell Constructions (steel, concrete, brick, etc.).
- The effect of various factors on efficiency and performance.
- Data on CMP (Combination Multiclone-Precipitator) Units.

. . . and many other helpful facts on Cottrell design and operation.

Latest data from Western Precipitation on Cottrell Recovery Equipment

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A copy of this data-packed booklet will be sent free to engineers and other executives interested in recovery processes. Send your request to our nearest office.

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Highlights of Nuclear Engineering and Science Congress—I

THE same techniques long used for selection of commercial plant sites for the chemical industry were employed by the du Pont Company in locating the Savannah River Plant of the Atomic Energy Commission, according to **C. H. Topping** of the du Pont engineering department. Site selection necessarily involves both judgment and experience, but both must be backed with an orderly, logical, efficient plan for progressive elimination of sites found undesirable, evaluation of acceptable sites and selection of the best one.

Basic data for the plant must be collected on such subjects as raw materials, finished products, water, wastes, transportation, labor, acreage and power. Then a preferred region, which may be as large as several states or as small as a part of a state, must be determined on the basis of differential costs affecting construction, transportation, power and taxes. A third step is an office study to find good sites within the region, eliminating any that lack essential requirements. Stream capacity for waste disposal and quantity and quality of water supply may be important considerations at this stage of the selection process. Available labor supply, railroad access, and suitability of terrain must also be considered at this stage.

The fourth major step is preliminary field inspection, which generally can be made out from public roads by observing new developments not shown on maps previously studied and by ascertaining the nature of surface soil and the amount of timber or crop cultivation. Preliminary selection and optioning of the best two or three sites is the fifth step following which the most important step of evaluation for final selection is taken.

In evaluating for final selection water supply and disposal facilities are checked; missing data on transportation are collected; labor supply and factors affecting labor relations are investigated; topographic maps and test borings are made, and data on fuel and power are firmed up; differential costs for capital investment are tabulated and operating costs are estimated; and qualitative factors such as community attitudes and effect of local industries are compared on the basis of judgment and experience.

Mr. Topping revealed that this commercial procedure was followed with few exceptions in locating the Savannah River Plant of the AEC on a site in South Carolina near Augusta, Georgia. Basic data were mutually developed by AEC and du Pont for this reactor plant, which was considered as a highly specialized processing plant.

Selecting was eventually narrowed to four sites, with the final recommendation being based on essentially the following conclusions: One of the warm water sites has water of such quality as to impose a potentially unacceptable risk to the continuity of operations unless demineralized at great cost. The flourishing food farming area surrounding one of the cold water sites represents a possible formidable hazard. The other cold water site does not possess the impelling advantages which would make it acceptable in its location outside the preferred region. The Savannah River site more nearly meets the requirements than do the others.

As the atomic energy industry progresses management will want to locate its plants near populated areas where its markets exist, according to **Arthur E. Gorman** of the U. S. Atomic Energy Commission in a paper entitled, "Waste Disposal as Related to Site Selection." There has been considerable concern among people and public officials concerning this movement toward established communities, but it is lessening as knowledge of available effective controls over radiation hazards is disseminated. There is increasing interest in problems of disposal of radioactive and toxic wastes. A fundamental step in resolving problems is careful appraisal of environmental factors related to sites under consideration for new plants. Such appraisals call for a wide area of competency in the professions dealing with waste disposal and environment and particularly with site geology, hydrology, and meteorology. The Atomic Energy Commission has anticipated the day when this industry would move toward populated areas and through research, development and service contracts with other federal agencies, universities and private institutions has developed a fund of experience and knowledge which is now available to private industries.

In case of nuclear reactors and chemical processing plants special problems exist in disposal of high-level radioactive and toxic wastes. There is good evidence, however, that with careful site selection, good design of plants and facilities use of atomic energy and nuclear materials can be carried out reasonably near populated areas. Public officials are gradually acquiring technical knowledge concerning the atomic energy industry its technology, its terms and its standards and are cooperating with Atomic Energy Commission in assisting in resolving some of the pressing problems in site selection and waste disposal.

According to **Fred D. White** and **Donald H. Pack** of the U. S. Weather Bureau, specific applications of meteorology to the problem of gaseous waste disposal will include two main fields, engineering design, and plant operations. In the field of engineering design, meteorological information may be used to select a site that is favorable for the use of the atmosphere to dispose of waste gases. Information may be furnished on the placement and orientation of buildings at a site so that no one building is persistently affected by gases from another source. If the character of a site is such that lateral dispersion is limited, buildings may be spaced (based on theoretical equations and actual meteorological data) to avoid points of maximum concentrations. If computations indicate that untreated gases will result in concentrations higher than desirable, meteorological data can be considered in the choice of stack heights sufficient to obtain tolerable concentrations without unnecessary expenditures to achieve the objective.

If the majority of inversions lie below a reasonable height, stacks may be constructed to vent gases above the inversion, thus obtaining the increased dilution of the more unstable air aloft and utilizing the inversion barrier to prevent the downward spread of contaminants. Without precise meteorological information, it would be difficult to obtain such an advantage other than by chance. In addition to the use of tall stacks, the volume and/or toxicity of waste gases may be reduced by absorbers, filters, scrubbers, etc. The capacity of these devices may be fitted to the capacity of the atmosphere at a particular location and time to disperse materials. In applying meteorological data to plant operation, the meteorologist may be asked to compute concentrations resulting from specific operations; and, if necessary, a program may be instituted to control operations based on meteorological information. Such control could consist of limiting the effluent volume so that ground con-

centrations are kept below a certain value. Or, alternatively, the release of waste gases may be scheduled only for times when meteorological conditions favor the rapid spread and dilution of the released material.

Design of Second Experimental Breeder Reactor

A step toward the ultimate commercial use of nuclear reactors in central station power plants was described by **L. J. Koch** of Argonne National Laboratory in a paper entitled "The Engineering Design of EBR-II." The Argonne Experimental Breeder Reactor II (EBR-II) is one of the five prototype industrial power reactors selected by the United States Atomic Energy Commission for development and construction. It is a plutonium-fueled, unmoderated, sodium-cooled reactor with a power rating of 60,000 kw (heat). The plant consists of the reactor and heat removal system, the steam-electric power plant, and an integral fuel reprocessing facility. The plant is now in the engineering design and development stage, with construction scheduled to begin in 1956, and operation to begin in 1958.

The heat produced in the reactor is removed by the primary sodium system, and transferred to the secondary sodium system in the intermediate heat exchanger. The secondary sodium transfers its heat in the steam generator to produce a maximum of 200,000 lb per hr of superheated steam which is delivered to the throttle valve of a 20,000-kw conventional condensing turbine at 850 F and 1250 psig. Five stages of feedwater heating are employed. The primary sodium becomes intensely radioactive in passing through the reactor, and a secondary, non-radioactive, sodium system is employed to isolate the radioactive sodium from the steam generator.

The plant includes an integral fuel and fabrication facility to determine the feasibility and cost of a fuel cycle specifically designed to meet the needs of a fast breeder reactor. Low reprocessing costs, and a short cooling time to minimize fuel inventory, are desired. A direct metallurgical separations process has been selected for EBR-II fuel recovery which promises to accomplish both of these objectives, but requires remote controlled, shielded fabrication of the fuel elements.

The reactor consists of an enriched core of uranium-plutonium alloy, in the approximate shape of a hallow cylinder, surrounded on all sides by a uranium breeding blanket. The average core power density is approximately 1000 kw per liter, and the average core heat flux is approximately one million Btu per square foot per hour.

The reactor is approximately 6 feet is diameter by 6 feet long and is divided into four main zones; central blanket, core, inner blanket, and outer blanket. Each zone is comprised of a number of right hexagonal subassemblies (2.3 in. across flats of the hexagon) containing the fuel or blanket elements. All subassemblies are of identical size and total 637. Twelve control rods which consist of modified movable fuel subassemblies are located at the outer edge of the core. Reactor control is effected by moving these rods in a vertical direction and thus moving fuel into, or out of, the core.

The EBR-II plant employs pyrochemical fuel processing which involves high temperature slagging in the molten metal phase. The costly conversion steps required in aqueous systems are avoided, and the size and complexity of the equipment are reduced considerably. However, the process is not as efficient, and com-

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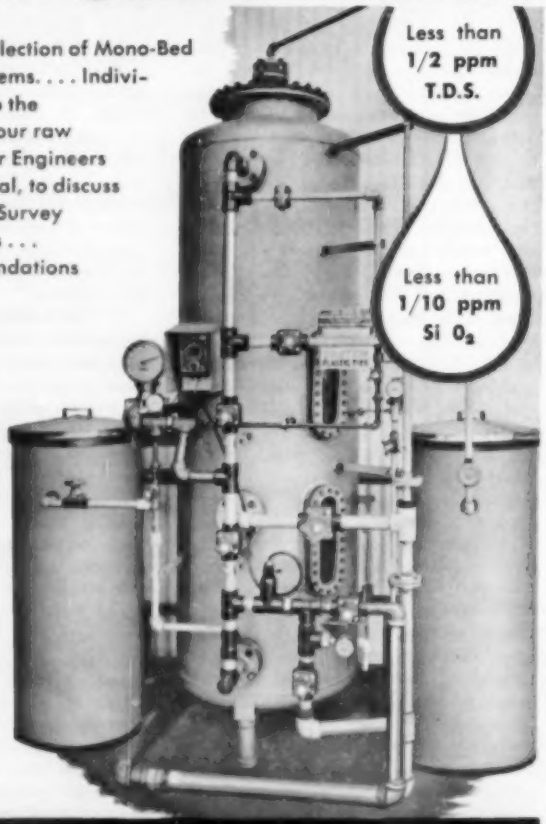

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plete decontamination is not obtained. The results to date indicate that in excess of 90 per cent of the fission product activity can be removed by the process. This is an acceptable decontamination for fast reactor operation, because it is relatively insensitive to fission product poisoning. Sufficient residual fission product activity remains in the fuel, however, to require shielded remote control fabrication of the alloy. After processing, therefore, it is necessary to reconstitute and fabricate the material, and assemble the fuel elements, completely by remote control methods. The fuel is fabricated into pins, loaded into the fuel element tubes, and assembled into the subassemblies.

Nuclear Power Economics

Much discussion has taken place regarding the eonomics of small nuclear reactor plants for power generation in so-called underdeveloped areas. A paper by **T. F. Nagey** and **W. W. Wachtl** of Glenn Martin Co. explained a general method of evaluating the economics of any enriched reactor system independent of power level or cycle thermodynamics.

For plants under 10,000 kw which are remotely located, the components must be simple, the overall system small, and the efficiency high. A water-cooled and moderated reactor is by far the easiest to build at this time for such an application. However, the maximum expected cycle efficiency is about 20 per cent, and this cannot be greatly improved even if the reactor could be located at a site containing abundant cooling water.

Some improvement in overall efficiency could be obtained by using a reactor cooled by a liquid metal and transferring its heat to water. The higher temperatures possible by liquid metal systems can be had more easily and directly by employing a direct gas cycle with a solid moderator. The gas cycle, with its inherent high temperature characteristics, offers much for small power plants. For these plants the gas cycle efficiency can increase more than twice as fast as the steam cycle efficiencies for a given increase in top temperature above 1000 F.

A second paper on reactor economics was presented by **R. W. Kupp** of Atomic Power Development Associates, Inc. Fast neutron breeder reactors have inherently a relatively short core fuel cycle. This short fuel cycle together with long decay times necessary for direct fabrication and cooling prior to processing entails a very significant fuel inventory charge. Pyrometallurgical reprocessing schemes combined with a remote fabrication operation hold promise of a minimum cost cycle for fast reactor reprocessing. The total cycle cost of a large plant installation may be on the order of $^1/_2$ to $^3/_4$ that of an aqueous plant cycle.

In a paper entitled "Economic Power Fueling Without U-235 Enrichment," **W. B. Lewis** of Atomic Energy of Canada, Ltd., pointed out that the three costs are the cost of fissile fuel supplied as makeup against consumption; the charges on the inventory of fissile fuel; and the cost of processing and refabricating irradiated fuel. This includes all handling costs after the first insertion in the reactor. The four rules for economic fueling are (1) buy the cheapest fissile fuel; (2) regenerate it; (3) use it at a high power rating; and (4) minimize reprocessing.

Mr. Lewis added that there are two restrictions: (1) the need to maintain reactivity; and (2) the need to remove the heat without letting the fuel, its sheathing or the coolant exceed certain temperature limits.

"Economics of Radiochemical Plants" was the subject of a paper by **W. G. Stockdale** of Oak Ridge National Laboratory. The paper is limited to data on known and proven solvent extraction processes in the field, obtained from direct maintenance costs, and is based on facilities built and operated for the Atomic Energy Commission by private contractors.

In radiochemical separation plants, there is one fact that has no duplicate in the chemical industry, namely the raw materials feed to the plant is radioactive. The fact is responsible for the abnormal costs, and the effect is felt in each and every area. In the process area radioactivity must be considered from two standpoints: (1) criticality, that is, control by vessel spacing, geometry, batch size, or concentration to ensure that the process material will not under any circumstances lead to a self-sustaining neutron chain reaction, and (2) protection of personnel from beta and, even more dangerous, gamma radiation.

Criticality affects the building size by dictating the number and spacing of vessels. Radiation protection affects the building design and cost by making remote operation mandatory behind or inside heavily shielded cubicles, cells, or canyons. Shielding usually consists of concrete walls up to 6 ft thick, depending on the intensity of the gamma radiation emitted from the process streams and vessels.

Because of the complexity of process equipment and piping, all labor costs are higher than for comparable items in the ordinary chemical industry. Process equipment specifications call for rigid welding and inspection procedures. Piping must be either installed with all metal contact fittings, subject to careful and painstaking installation for insurance against leakage, or must be all welded. Process equipment and piping in critical locations are often duplicated to maintain on-stream time

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Direct operating labor for a radiochemical plant will usually consist of five men per shift plus supervision. Supporting labor consists of analysts sufficient to staff the laboratory, health physicists, common labor, all crafts for maintenance, and office, engineering and administrative personnel. Additional personnel for plant improvement investigations are usually included. Total payroll for operation of a radiochemical plant will approximate 150 people.

Technology of Water Treatment

In a paper entitled "Removal of Radionuclides from Water by Water Treatment Processes," **Roy J. Morton** of Oak Ridge National Laboratory and **Conrad P. Straub** of Robert A. Taft Sanitary Engineering Center, Cincinnati, reported on an investigation of conventional water treatment procedures and several modified and non-conventional processes for the removal of radioactive materials from water. Processes studied included coagulation with aluminum and iron salts, phosphate coagulation, lime-soda softening, ion-exchange, sand filtration, electrodialysis, adsorption by slurried clays and metal dusts, and distillation.

In general, conventional coagulation was ineffective except for isotopes of valence 3, 4, and 5. Phosphate coagulation and lime-soda softening with careful control showed relatively high removals of strontium and certain other isotopes. Iron dust and clay soils are good adsorbents under favorable conditions. Distillation and ion exchange are efficient but expensive.

According to **L. R. Setter** and **A. S. Goldin** of Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, in a paper entitled "Measurement of Radioactivity in Water," the determination of the extent and significance of the radioactive water pollution requires a background involving current levels of gross alpha and beta radioactivity and some knowledge of the source of contamination with respect to the kinds of radioisotopes. Methods have been developed and surveys made on the natural back-

ground radioactivity. Some of the methods, though involved, have high specificity in defining the principal background due to the daughter elements of uranium and thorium. Other methods are simple but less specific. In either case, artificial radioactive contamination can be expected to cause some interference.

The gross alpha and beta measurements can be assayed at high overall efficiencies. One such method for low level measurements is described. The method is sensitive to 10 to 30 per cent of the maximum permissible concentration for unknown isotopes. With ancillary data on the kind of radioisotopes present, this measurement should be quite adequate for estimating the current hazards. Eventually, when the history of contamination becomes obscure or more uncertain, it will be necessary to develop accurate, discriminatory technics for separately measuring the more hazardous of radioisotopes. Studies in this direction are desirable. Fortunately, the more hazardous water contaminants of nuclear energy operations consist of only a few isotopes in mixed fission products such as strontium-90, strontium-89, and iodine-131. Further studies, utilizing possibly a combination of precipitation and solvent extraction, can be expected to evolve quantitative methods for assaying low levels of specific isotopes in wastes and waters for a more reliable interpretation of the overall significance of radioactive contamination.

William E. Dobbins of New York University pointed out that biological methods will have limited application for the removal of radioactivity from liquids. The extent of the removal of a radioactive element from a liquid waste by biological methods depends upon the biochemical relationship which exists between the element and the biological system, as well as the chemical composition of the waste. For those elements in cation form the removal will be greatest for those having high valence states. Probably the best application of biological methods is for the treatment of low activity level laundry wastes which contain complexing agents which interfere with chemical treatment methods.

The outlook for adequate supplies of water suitable quality for nuclear energy development is more favorable in some parts of the country than in others, according to a report by **S. K. Love** and **W. F. White** of U. S. Geological Survey. Competition for

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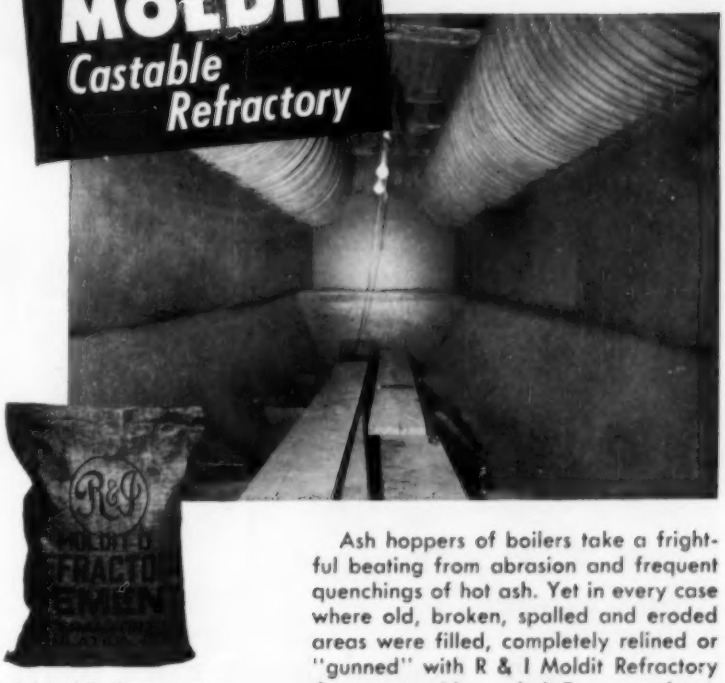

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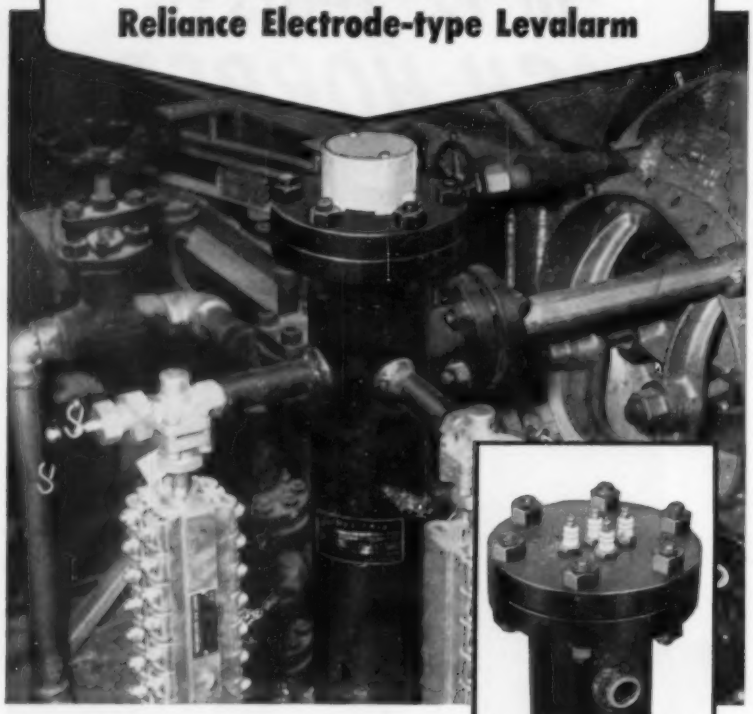

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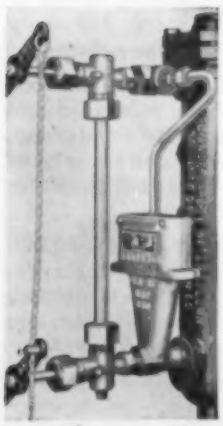

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water in some areas is extremely intense and may pose a real limitation on the development of nuclear installations.

Development engineers and other scientists responsible for expansion of nuclear engineering projects are urged to give early and thorough attention to water requirements with reference to existing or potential availability of water supplies. The program of waste disposal from nuclear installations also must be planned carefully so that receiving streams and underground waters will not be rendered dangerous or unsatisfactory for subsequent use.

Many problems of measurement of radioactivity in water are still unresolved. Additional research in field and laboratory techniques are necessary in order that more reliable data can be obtained.

It is imperative that leaders in the field of nuclear engineering lend their support and actively participate in investigational programs that have as their objective the development and conservation of adequate supplies of water for all beneficial uses including the expansion of nuclear energy installations.

J. W. Boyle, W. F. Kieffer, C. J. Hochanadel, T. J. Sworski, and **J. A. Ghormley** of Oak Ridge National Laboratory reported that the decomposition of aqueous solutions of uranyl sulfate, uranyl fluoride, uranyl nitrate, and uranium (IV) sulfate has has been studied as a function of uranium concentration, isotopic enrichment, temperature, pH, and added solutes. Except for the nitrate, no net change of the solute itself was observed, and the net effect was that of water decomposition to H_2, O_2 and peroxide. The initial yield of hydrogen decreased on lowering the ratio of fission-recoil energy to total energy and decreased on increasing the uranium concentration or the hydrogen-ion concentration. The yield was independent of temperature, anion, oxidation state of uranium, and the presence of some added solutes.

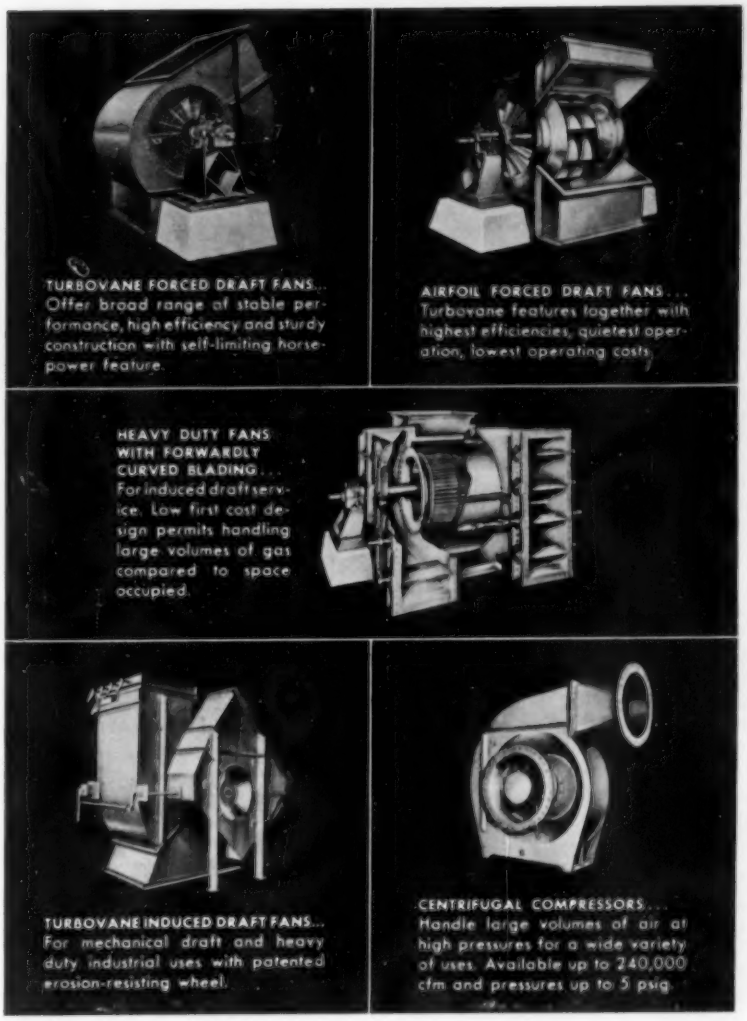
Three engineers associated with the Bettis Plant of Westinghouse Electric Corporation, **D. M. Wroughton, J. M. Seamon,** and **H. F. Beeghly,** presented a paper entitled, "Water Technology for Primary Systems in Water-Cooled Power Reactors." In sharp contrast to the evolutionary developments of water technology for conventional steam power plants, water technology for nuclear power plants of the pressurized light water type employing stainless steel systems

is now based on a few years of development work and even fewer years of operating experience with full-scale plants.

The water in the primary system of the pressurized reactor should be of high purity because radioactivity will be induced in impurities; it should also be noncorrosive and non-fouling in nature, for obvious reasons. Conventional water treating methods are employed and usually involve, at least as a final step, demineralization with a mixed bed of hydrogen-form cation exchange resin and hydroxyl-form anion exchange resin. The makeup water may also be (a) mechanically deaerated, (b) deoxygenated with a sodium sulfite-regenerated ion exchange resin, or (c) used with no dissolved gas removal.

After water has been added to the system and is being recirculated, its purity may be affected in several ways: (1) By contamination with corrosion products due to corrosion of any of the system materials in contact with the water. (2) By radiation-induced reactions of dissolved gases to form electrolytes such as ammonium hydroxide or nitric acid. (3) By nuclear transformations in the water to produce short-lived, but highly radioactive isotopes of nitrogen. (4) By intentional addition of gases or dissolved solids for corrosion inhibition or other purposes. (5) By intentional degasification, filtration, or demineralization of the water in a by-pass system to remove contaminating gases, suspended solids, or dissolved solids. (6) By fission product contamination due to rupture or penetration of the fuel cladding and subsequent corrosion or leaching of the fuel "meat."

In the absence of fission product contamination, potential fouling problems arise almost entirely from the circulation of suspended corrosion products in the primary system. Soluble corrosion products and other soluble impurities (from the makeup water) are kept at very low concentrations due either to low solubility limits in high temperature water or to intentional removal by by-pass demineralization. Concentrations of insoluble corrosion products are not, however, ideally transportable and tend to deposit or settle out at any point in a system where suitable conditions exist. Thus only a part of these insoluble products ever reach the by-pass filter. Tests have indicated that radiation tends to promote deposition of corrosion products. Other factors having an influence on deposition appear to be water chemistry, concentration of corrosion products in the water, and water velocity.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The authors reported that consideration is being given to the use of carbon steel in reactor systems. This has the advantage of better availability, greater experience in fabrication methods, and possibly easier removal of radioactive contamination from carbon steel surfaces. Some inherent disadvantages include higher corrosion rate during operation, greater sensitivity of localized attack and greater susceptibility to corrosion during fabrication, shipment, storage, installation and idle periods. While some of the potential problems cannot be fully investigated until full-scale systems are built, most of the results of the carbon steel development work to date are encouraging. With good control of water conditions, successful substitution of carbon steel for much of the stainless steel in these systems seems likely.

Hot Water Corrosion

In a paper entitled, "Apparatus for Visual Study of Corrosion by Hot Water" **Daniel R. Grieser** and **Eugene M. Simons** of Battelle Memorial Institute described the design and operation of a windowed autoclave suitable for studying corrosion of materials by pressurized hot water. A windowed autoclave was designed and constructed to permit visual study of the reaction of a corrosion specimen with high-temperature water. Although similar research is being done elsewhere, several features are unique. One advantage is that the upper temperature is limited only by stresses in the pressure vessel, rather than by corrosive attack on the glass windows. Another is that the hot water can be made to contact the specimen suddenly, which provides a more interpretable test than the case where the specimen is subject to attack during the time the system is being heated and pressurized.

The specimen is prepared and mounted in the desired position, after which the test vessel is closed and sealed. The preheat autoclave is loaded with 550 cc of water, and the entire system evacuated to outgas the water. With all the valves in the system closed, the preheat and viewing autoclaves are heated independently to the test temperature. The test is initiated by turning on the pressure recorder and then opening a valve to allow preheated water to enter the viewing autoclave and engulf the test specimen. When working at 600 F, this transfer is accomplished in less than 30 seconds. Simultaneously with opening the valve, the time-lapse control and the specimen and timer lights are turned on. From this time until the corrosion is complete, the operation is entirely automatic. When the test is over, the heaters and camera controls are turned off and the system is allowed to cool. The pressure record is continued until the system has cooled to room temperature. Then the quantity of water emptied from the window autoclave is measured.

The authors concluded that the windowed autoclave affords a relative evaluation of the influence of such variables as geometry, alloying, type of bonding, water temperature, and water impurities on corrosion rate. The most important advantage of this instrument is, however, that it provides a pictorial representation of the corrosion phenomenon while it is occurring.

Storage Tanks for Radioactive Wastes

One of the many problems introduced by the use of nuclear energy is related to the storage of high-level waste fission products. At a plant like the Savannah River Plant of the AEC fission products are produced at a level of radioactiveity which is too high by a factor of 10^{10} to permit immediate discharge to streams. In addition to the intense radioactivity, according to **Edgar E. Wilson** of the engineering department of the du Pont Company, who presented a paper on "Design Considerations of Storage Tanks for Radioactive Wastes," two of the fission products remain so active that even after 20 years the level of radioactivity is still too high by a factor of 10^8 for discharge to streams.

One solution to the problem is to install radioactive wastes storage tanks. Because of the severe design requirements and the large volume of liquids involved, these storage tanks constitute very large investments. Mr. Wilson described the design of a large steel primary storage tank having a diameter of 85 feet, a height of 27 feet and a total capacity of 1,070,000 gallons. The cylindrical portion varied in thickness from $^3/_8$ in. at the top to $^7/_8$ in. at the knuckle as determined by structural requirements owing to the bottom sludge temperature. The shell was to be constructed in accordance with the ASME code for unfired pressure vessels, with all welds completely radiographed.

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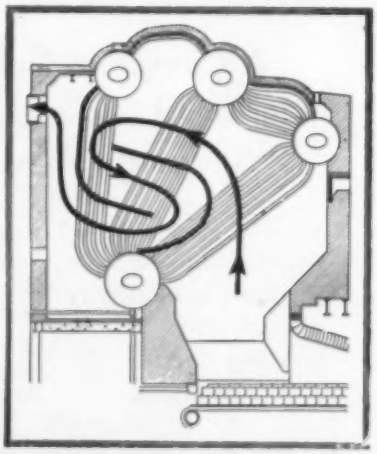

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To guard against leakage in the primary container a secondary container in the form of a steel saucer 90 feet in diameter and five feet high was fabricated of $\frac{1}{2}$ in. thick steel.

The primary container was housed in a reinforced concrete shell having a 3 ft, 6 in. thick bottom slab stepped to 5 ft, 4 in. thick at the center walls 2 ft, 9 in. thick, and the top 3 ft, 9 in. thick. The bottom thickness was determined structurally to withstand the 300 to 350 F temperatures in the sludge layer and to carry the weight of the central column. The wall thickness was determined by structural requirements. The elevation of the tanks was chosen so that the maximum liquid level in each tank was at or just below finished grade, with the top of the saucer being four feet above ground water.

Sodium Hydroxide Pump Loops

According to **N. E. Miller** and **E. M. Simons** of Battelle Memorial Institute who presented a paper entitled "Sodium Hydroxide Pump Loops," there is considerable incentive to find a suitable container material for the use of sodium hydroxide in nuclear reactors. In addition to its relatively low vapor pressure and favorable heat-transfer characteristics, NaOH has attractive nuclear properties in the form of rather low neutron-capture cross section and high hydrogen content for moderation. Furthermore, it is stable in the presence of radiation at elevated temperatures, as well as cheap and abundant.

The authors described the design and operation of small laboratory loops for investigating the influence of temperature, thermal gradient, and flow velocity on the corrosion of nickel by circulating NaOH. Results of corrosion are given for the temperature range of 900 F to 1500 F with thermal cycles from 70 F to 200 F. Above 1050 F, with a practical thermal cycle of 1000 F, the cool section of the system may become completely plugged by nickel deposition in a relatively short time. From present knowledge, it appears that low maximum temperature and small thermal cycle are required for a reasonable lifetime of an NaOH-cooled reactor.

Uranium-Bearing Coal

N. M. Denson, U. S. Geological Survey, Denver, Colorado, stated that during the five year period 1950 through 1954 the United States Geological Survey, in behalf of the Atomic Energy Commission, has undertaken an extensive investigation of the occurrence of uranium in coal and related carbonaceous rocks throughout large areas in the Rocky Mountain and Great Plains provinces. Many hundreds of coal outcrops have been tested radiometrically with the aid of portable and carborne scintillation equipment and many samples collected for chemical and spectrographic determinations Subsequently, several coal-bearing areas in North and South Dakota, Wyoming, and Idaho have been core drilled by the U. S. Bureau of Mines and the Geological Survey to determine the uranium content of coal beds below the surface. As a result of these investigations it is apparent that large tonnages of uranium are contained in the low-rank coals in some areas in Wyoming, Idaho, and New Mexico, and the northern Great Plains regions of eastern Montana and the Dakotas. In comparison with current sources of uranium that are being mined or developed today, most of these radioactive coal deposits are very low-grade, and contain 0.005 to 0.02 per cent uranium. The uranium content of the coal varies considerably over short distances and may contain 0.1 per cent or more in small areas.

Since the tonnages of coal containing small amounts of uranium are large, they are throught to form a resource of possible value. Detracting from their utilization as a possible resource of uranium is the fact that in general the more highly uraniferous coals have much higher ash contents and much lower heating values than do nonuraniferous coal and recovery of the uranium as a by-product of the ash would depend upon its suitability for use as fuel. Although no efficient method of extracting uranium has yet been developed, it is possible that the radioactive coal deposits, many of which are strippable, will eventually be utilized when new metal-

At times it pays to be blinded !

But certainly not when you analyze coal values. Before you contract or place an order for your coal supply, a comparative study of evaporative results should be made.

No coal is 100% efficient. But with a properly, uniformly sized coal you'll utilize a higher percentage of Btu content. This more efficient combustion means lower steam costs for you.

At our Enos and Enoco Mines . . .

specific gravity washing, exact sizing and mechanical size blending produce a coal free of loose impurities, tailored to your stoker requirements. Each shipment is guaranteed to be of the same uniform size-consist and high quality. You'll find that exactly sized, properly prepared Enos and Enoco coals reduce Btu waste.

Why not give us a call today? Let us *prove* that superior preparation of quality Enos and Enoco coals give you more efficient utilization of Btu content for lower steam cost.

Place a trial order.
Make a test comparison.

THE ENOS COAL MINING COMPANY

Sales Offices for Enos and Enoco Coals

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310 S. Michigan Ave. Chicago 4, Illinois

DO YOU WANT AN ENGINEERING JOB WITH A FUTURE?

THE OHIO VALLEY ELECTRIC CORPORATION, a new Company operating two large steam generating plants in the Ohio Valley has opportunities now for TEST (efficiency), METER, RELAY, and COMMUNICATIONS Engineers. If you have an engineering degree and are interested in a fine opportunity, write Personnel Director, Box 468, Chillicothe, Ohio.

lurgical techniques and recovery processes are developed. At one place in northwestern South Dakota on the southern flank of the Williston Basin coal in beds up to 24 inches thick, containing as much as 6 per cent and averaging 0.7 per cent uranium, has been discovered recently. This discovery suggests that other deposits of uranium-bearing coal of comparable grade may occur in the Western States.

Personals

Thomas R. Darmody has been named an assistant general manager of Vitro Engineering Division according to an announcement by Vitro Corporation of America.

Carl Claus has been named director of staff of The Babcock & Wilcox Co. according to an announcement made recently by **Alfred Iddles,** president. In his new position Mr. Claus will coordinate the various staff functions of the company, and will supervise the activities of the following departments and personnel: patent, N. Y. office personnel, student recruitment and training, employee training, the director of purchasing, public relations, advertising and publicity.

T. E. McBride, president of Cochrane Corp., has announced the appointment of **G. M. Wallace & Co.** as representatives in the Rocky Mountain district, for their complete line of water conditioning equipment, steam specialties and condensate return systems.

Robert M. Van Sant, director of public relations of the Baltimore and Ohio Railroad, retired October 1 after 42 years of service with that company. He was succeeded by **Joseph L. Stanton,** assistant director.

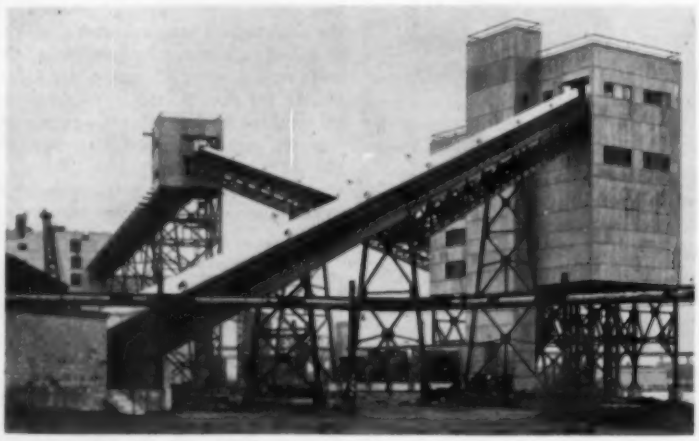
The following new appointments in the sales organization of Allis-Chalmers Mfg. Co.'s Industries Group have been announced: **V. L. Spinney,** manager of New York district since 1949, has been named manager of the central region, with headquarters in Cleveland, succeeding **R. L. Halsted,** who was recently appointed manager of the firm's processing machinery department; **N. W. Landis,** manager of the Detroit district office, has been named manager of the N. Y. district succeeding Mr. Spinney; and **A. J. Mestier, Jr.,** for the last five years manager of the Syracuse district, succeeds Landis as manager of Detroit.

G. N. Proctor, vice president of The Permutit Co., has been elected a member of the board of the Simplex Valve & Meter Co. Mr. Proctor, associated with both concerns since 1944, was elected vice president of Simplex in 1950.

R. Y. Case, assistant manager and chief engineer, power transmission department, U. S. Rubber Co., was awarded the Edward Longstreth Medal of the Franklin Institute at the Institute's Annual Medal Day ceremonies. Mr. Case was cited for his "timing belt," a new and radically different medium for the transmission of power.

B & W BOILERS FOR SALE

2 Babcock & Wilcox 600 HP each, Sterling bent tube, 4-drum, new 1939–40, ASME built, Hartford Inspection HSB-11925, Class 50, No. 23, 200-lb. design, complete with stokers, meters, ash conveying system, feed water system, oil remover system, complete installation, erected Chicago as last used until Summer 1955; tremendous bargain, inspection invited, communicate with owners. Address inquiries in care of Combustion Publishing Co., Inc., Box 600, 200 Madison Ave., New York 16, N. Y.



600 T. P. H. Coal Handling Installation at Astoria Station, Consolidated Edison Company of New York, Inc.

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Fig. 855 STAINLESS

Fig. 8 IRON

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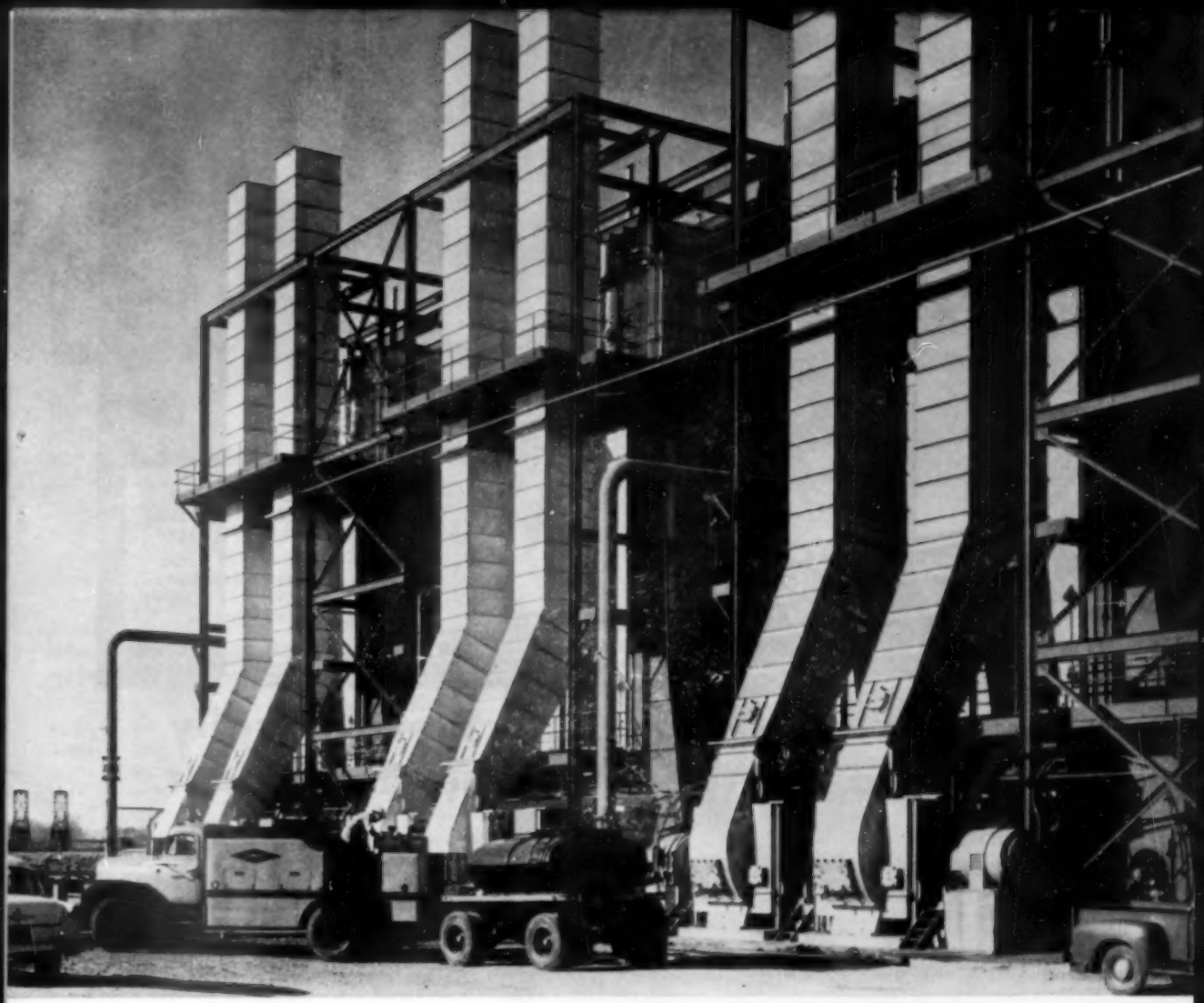


BOILER TUBE FAILURES ELIMINATED

Regular program of DOWELL chemical cleaning for six boilers ended tube failures due to scale

The tubes of a 500,000 pph boiler in a chemical plant contained an extremely hard high-silicate scale up to 1/16-inch thick. Mechanical cleaning was unsatisfactory, because it required a long shutdown and still left hard scale in the tubes.

Dowell engineers formulated a special solvent and quickly removed the scale from the boiler. The operator now has all six of the 500,000 pph boilers on a regular schedule of Dowell chemical cleaning. Since the beginning of this program, the boilers have been cleaned several times and there have been no tube failures caused by scale deposits.

Chemical cleaning is designed to add years of life to your equipment by helping to protect it from over-heating, galvanic attack, and pitting-type corrosion. Downtime is held to a minimum, because solvents are introduced through regular connections . . . extensive dismantling and scaffolding are not needed.

Dowell Service brings you over a decade of experience in the chemical cleaning of many kinds of equipment, including more than 10,000 high- and low-pressure boilers. Contact the nearest Dowell office for more information. Or write Dowell Incorporated, Tulsa 1, Oklahoma, Dept. A-27.

chemical cleaning service for industry

DOWELL

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

CONTROL OF OVER 130 BOILER FUNCTIONS
at Ridgeland Station, Chicago is centralized on these Republic electronic benchboards.

Controlling Combustion Electronically at World's Largest Cyclone-Fired Plant

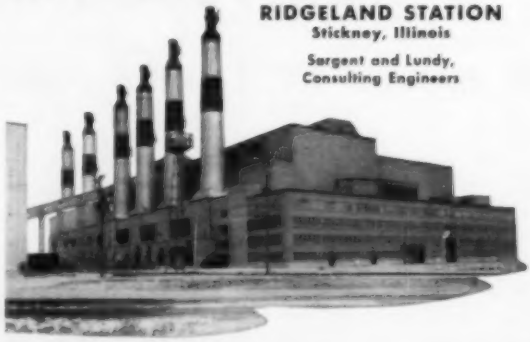
Commonwealth Edison's 640,000 KW Ridgeland Station near Chicago is the largest completely cylone-fired power plant in the world. A total of 28 cyclone furnaces fire the plant's six boilers.

To maintain maximum firing efficiency, combustion conditions at each cyclone are individually controlled and integrated with over-all plant operation by a Republic Electronic Combustion Control System. The system provides separate controls for primary air, secondary air, fuel feed and fuel-air ratio at each of the 28 cyclone furnaces in addition to controlling forced and induced draft fans and feedwater pumps on each boiler. All told, there are more than 130 individual controls which are automatically coordinated for continuous proper combustion.

Republic Electronic Controls handle all of these functions without introducing transmission lags, complicated pneumatic-mechanical linkages and inaccuracies due to mechanical inertia into the control system. Integration of control information is greatly simplified by use of electronic circuits. Expensive panel piping is eliminated and control panels are easier to operate. Because transmission of control impulses is electrical, all parts of the control system can respond simultaneously for smooth, coordinated operation of the boilers.

Ridgeland is but one of many modern cyclone-fired power plants that are equipped with Republic Combustion Controls. In fact, more cyclones are controlled by Republic than by any other make of controls.

Republic makes a complete line of combustion controls for all types and sizes of boilers, all methods of fuel firing, all load conditions and all arrangements of draft. Write us when your problem is combustion controls.



RIDGELAND STATION
Stickney, Illinois
Sargent and Lundy, Consulting Engineers

REPUBLIC FLOW METERS CO.
2240 Diversey Parkway, Chicago 47, Illinois

Scandinavia increases steam capacity, cuts costs burning coal the modern way

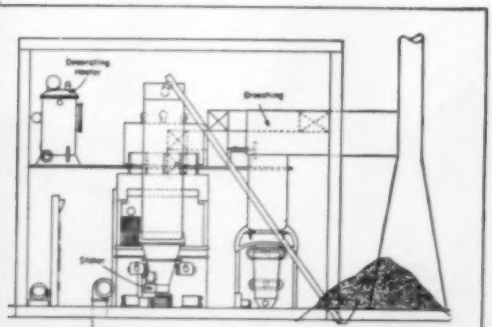
With its old power equipment overloaded by an ever-increasing demand for steam, Scandinavia Belting Co., Charlotte, N.C., took stock of its power situation. Boiler room efficiency was low and maintenance excessive; pressure fluctuated and labor costs had become a problem. Deciding to modernize, Scandinavia instituted a survey of all available fuels. On the basis of cost, coal was chosen. Today, after modernization, Scandinavia's power plant has increased steam capacity 150%, reduced fuel costs 15% and cut labor costs 70%. Increased efficiency and automatic operation have reduced the work force and assured a dependable steam supply at steady pressure with ample reserve for load growth. In addition, the cleanliness of the new plant has been an important factor in raising the morale of the employees.

facts you should know about coal

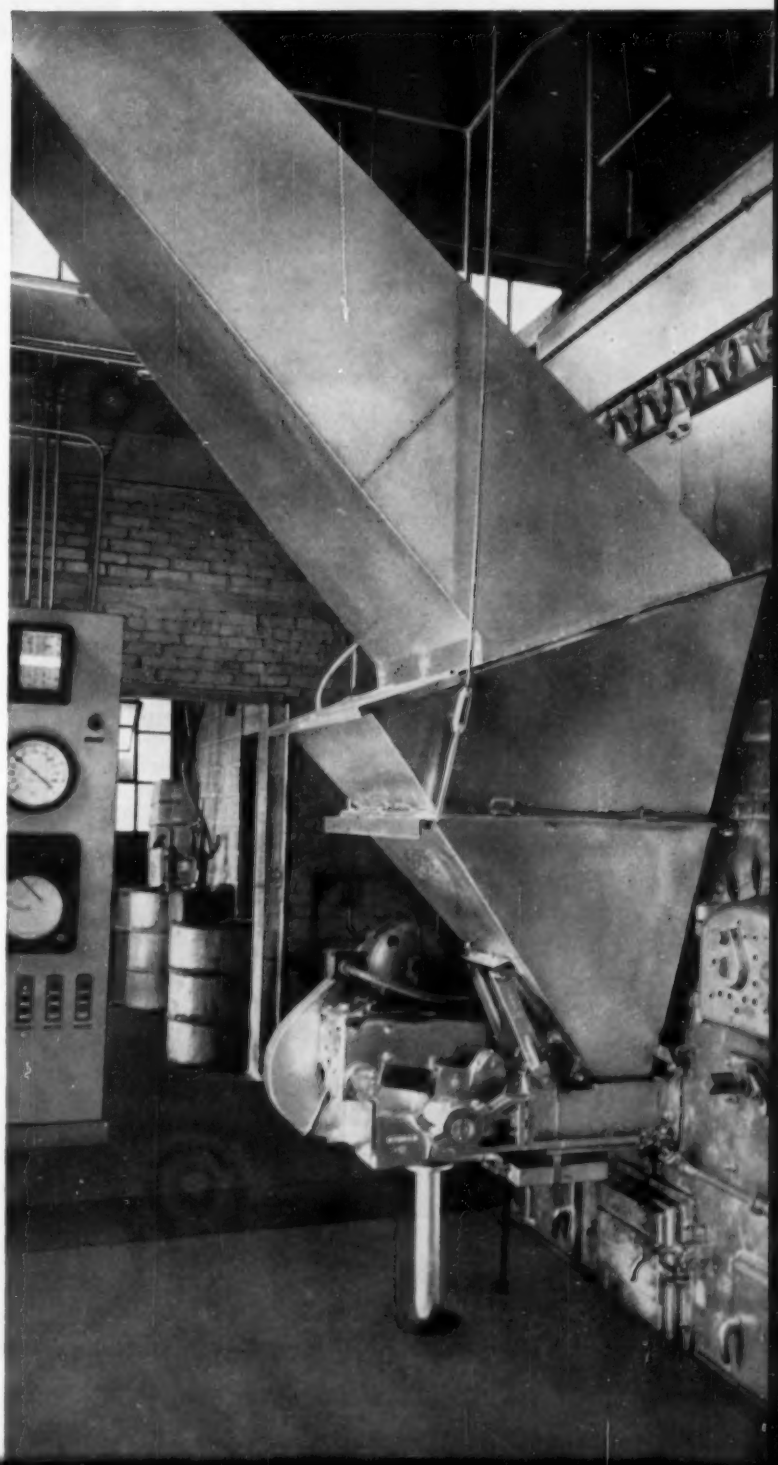
In most industrial areas, bituminous coal is the lowest-cost fuel available • Up-to-date coal burning equipment can give you 10% to 40% more steam per dollar • Automatic coal and ash handling systems can cut your labor cost to a minimum • Coal is the safest fuel to store and use • No smoke or dust problems when coal is burned with modern equipment • Between America's vast coal reserves and mechanized coal production methods, you can count on coal being plentiful and its price remaining stable.

For further information or additional case histories showing how other plants have saved money burning coal, write to the address below.

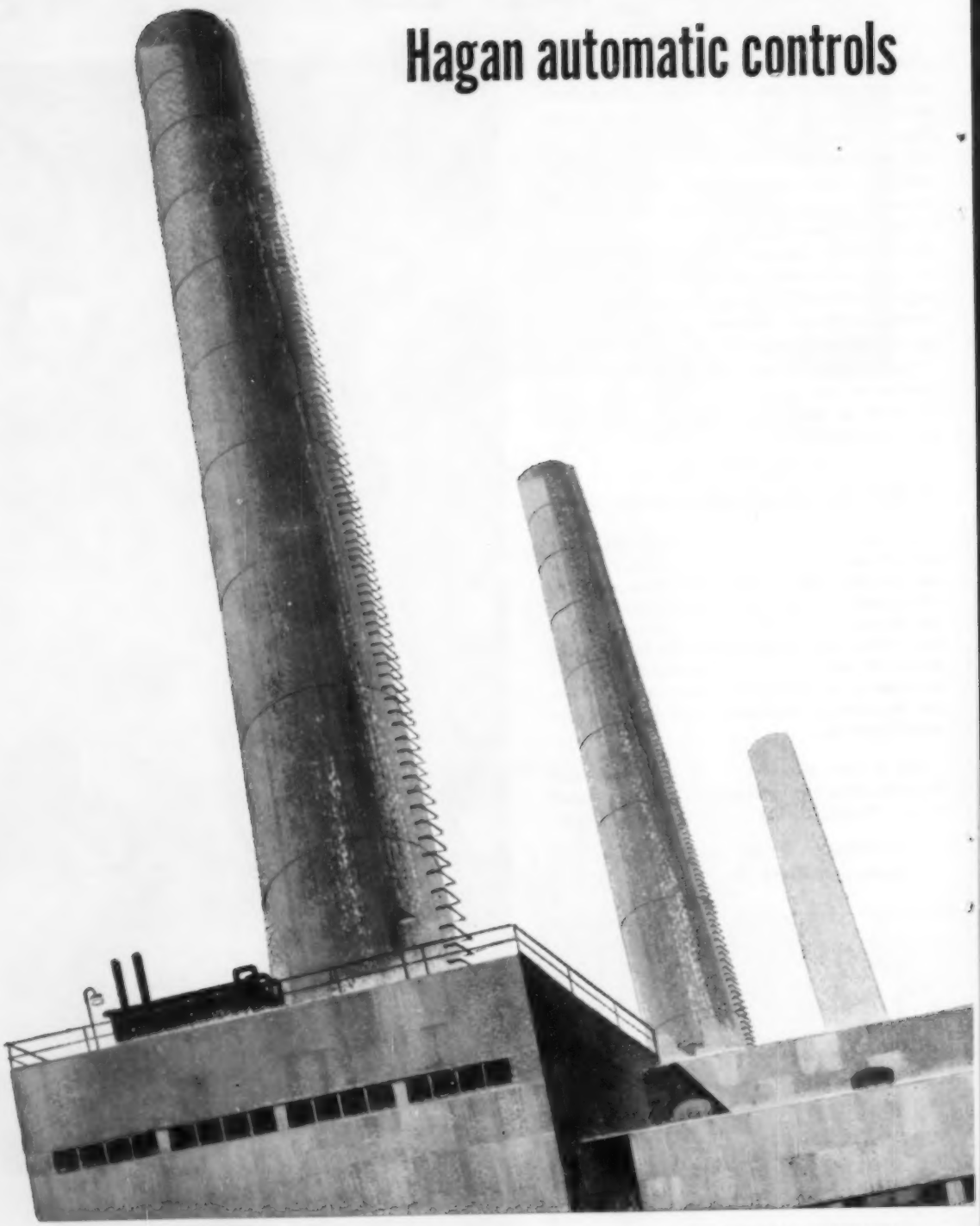
NATIONAL COAL ASSOCIATION
Southern Building, Washington 5, D.C.



Elevation of Scandinavia's Power Plant



Hagan automatic controls



chosen for 5 of the largest boilers in the world!

Complete Hagan Automatic Control Systems have been chosen for 5 of the Largest Boilers in the World. Three different boiler manufacturers are represented in the Big Five, and the burners, pumps, fans, etc., are supplied by a variety of manufacturers. But take a look at the control systems for the Big Five:

	Boiler No. 1	Boiler No. 2	Boiler No. 3	Boiler No. 4	Boiler No. 5
Combustion Control	HAGAN	HAGAN	HAGAN	HAGAN	HAGAN
Three Element Feed Water Control	HAGAN	HAGAN	HAGAN	HAGAN	HAGAN
Reheat Control	HAGAN	HAGAN	HAGAN	HAGAN	HAGAN
Feedwater Pump By-Pass Control	HAGAN	HAGAN	HAGAN	HAGAN	HAGAN
Steam Temperature Control	HAGAN	HAGAN	HAGAN	X	X

It is natural that the Big Five chose complete Hagan instrumentation and control systems. For over 35 years, Hagan controls have paced each advance in boiler construction and size. The engineering know-how developed by the design and construction of automatic control systems for boilers of all types and sizes constitute one of the major reasons for Hagan's selection.

The Hagan instrumentation and control devices used in these systems are accurate, reliable and versatile. They are available to the power plant engineer as standard components for extension and modernization of existing facilities.

Hagan systems are in successful operation throughout the world. Call on your Hagan Engineer when you have an Automatic Combustion Control problem.

HAGAN CORPORATION

HAGAN BUILDING • PITTSBURGH 30, PA.

Systems and components for: Boiler Combustion Control, Process Control, Metallurgical Furnace Control, Aeronautical Testing Facilities • Industrial Water Treatment • Chemical Water Conditioning

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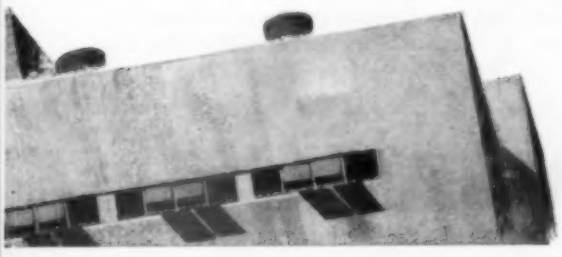
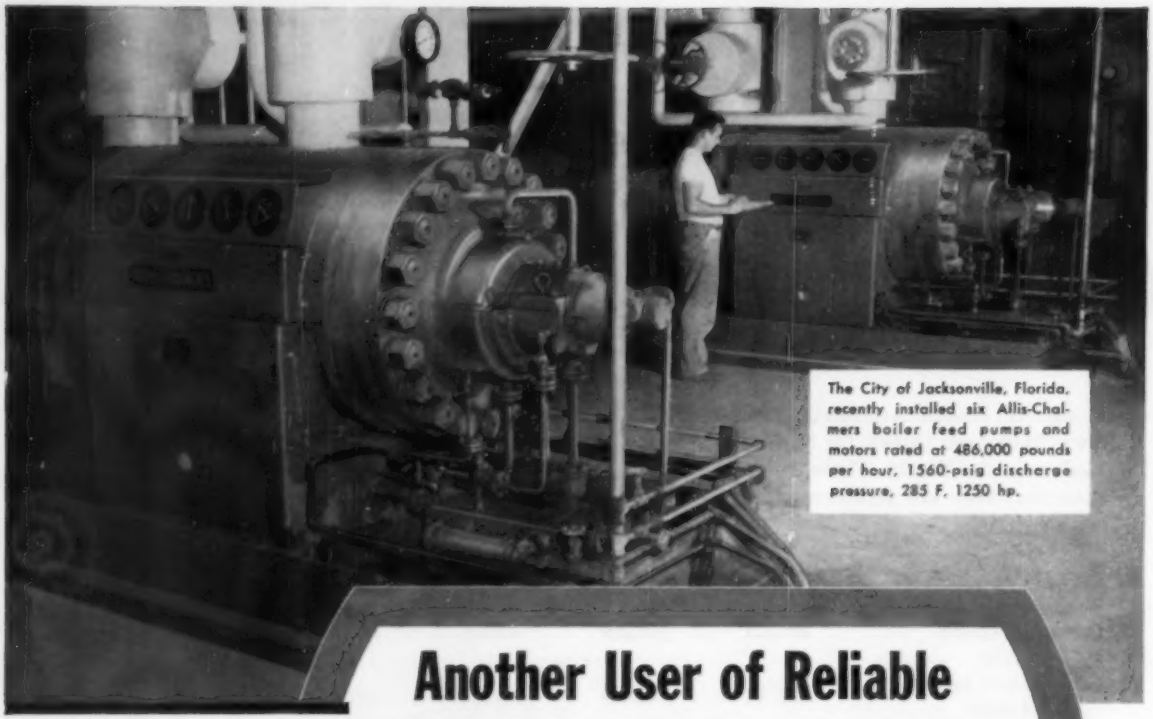




The City of Jacksonville, Florida, recently installed six Allis-Chalmers boiler feed pumps and motors rated at 486,000 pounds per hour, 1560-psig discharge pressure, 285 F, 1250 hp.

Another User of Reliable ALLIS-CHALMERS barrel-type PUMPS

City of Jacksonville

Here are the reasons **for wide acceptance of these pumps:**

- Outstanding performance — fully proved by service records.
- High efficiency and smooth operation under fluctuating loads — first stage has twin, single-suction impellers for low NPSH requirements.
- Simple maintenance—expansion joint and shaft seals are brought to outside of pump where they can be easily inspected.
- No balancing device needed—axial balance is maintained by back-to-back mounting of the impellers.

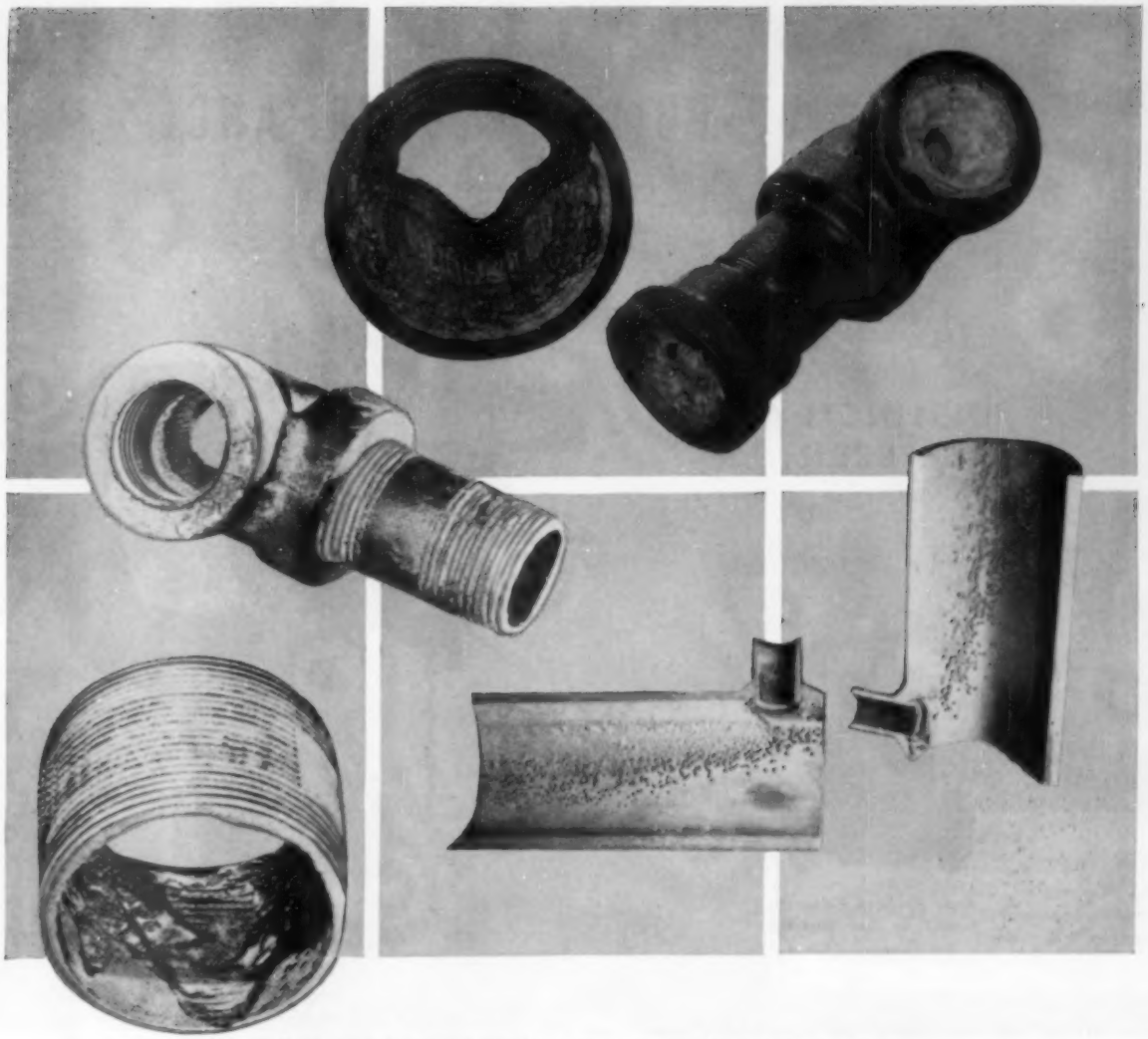
THERE are outstanding features like these throughout the Allis-Chalmers line. Whether you require boiler feed, condensate, circulating or other power plant pumps — it pays to standardize on Allis-Chalmers.

In addition, A-C can supply pumps, motors and control of coordinated design and manufacture. This means one responsibility — one guarantee of satisfaction.

Get complete information on barrel-type boiler feed pumps. Call your nearby A-C office or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin for Bulletin 08B7899.

A-4854

ALLIS-CHALMERS



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Each of these destroyed parts had to be taken out of service because of incomplete or inadequate water treatment. Replacement meant loss of steam production . . . new equipment expense . . . added labor-repair costs.

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CALL ON YOUR DEARBORN SALES ENGINEER for (1) analysis of raw water (2) recommendation of test procedures (3) proper treatment (4) a manually or automatically controlled feeding system.

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combatting corrosion wherever it occurs

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- ☐ Bulletin 5000—Water Treatment and Engineering Service
- ☐ Bulletin 5008—Dearborn 659 Anti-Foam
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Company.....
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Address.....
City.....*Zone*.....*State*.....

BAYER
STEPS UP BOILER PERFORMANCE

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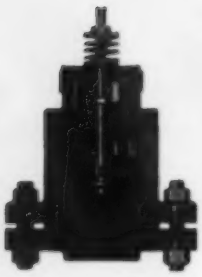
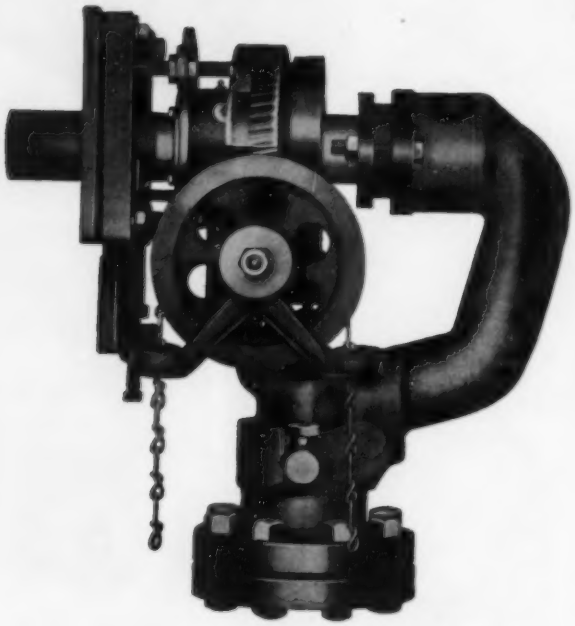


Bayer Balanced Valves are famous for their long life and continued tightness



Bayer Single Chain Balanced Valve Soot Cleaner

WITH THE Bayer Balanced Valve Soot Cleaner the balancing chamber above the piston disc impounds steam when the valve closes, thus relieving valve parts from shock. The valves remain *steam tight* because the dashpot action causes the valve to seat gently. Unbalanced valves close with a hammer stroke and soon become leaky.

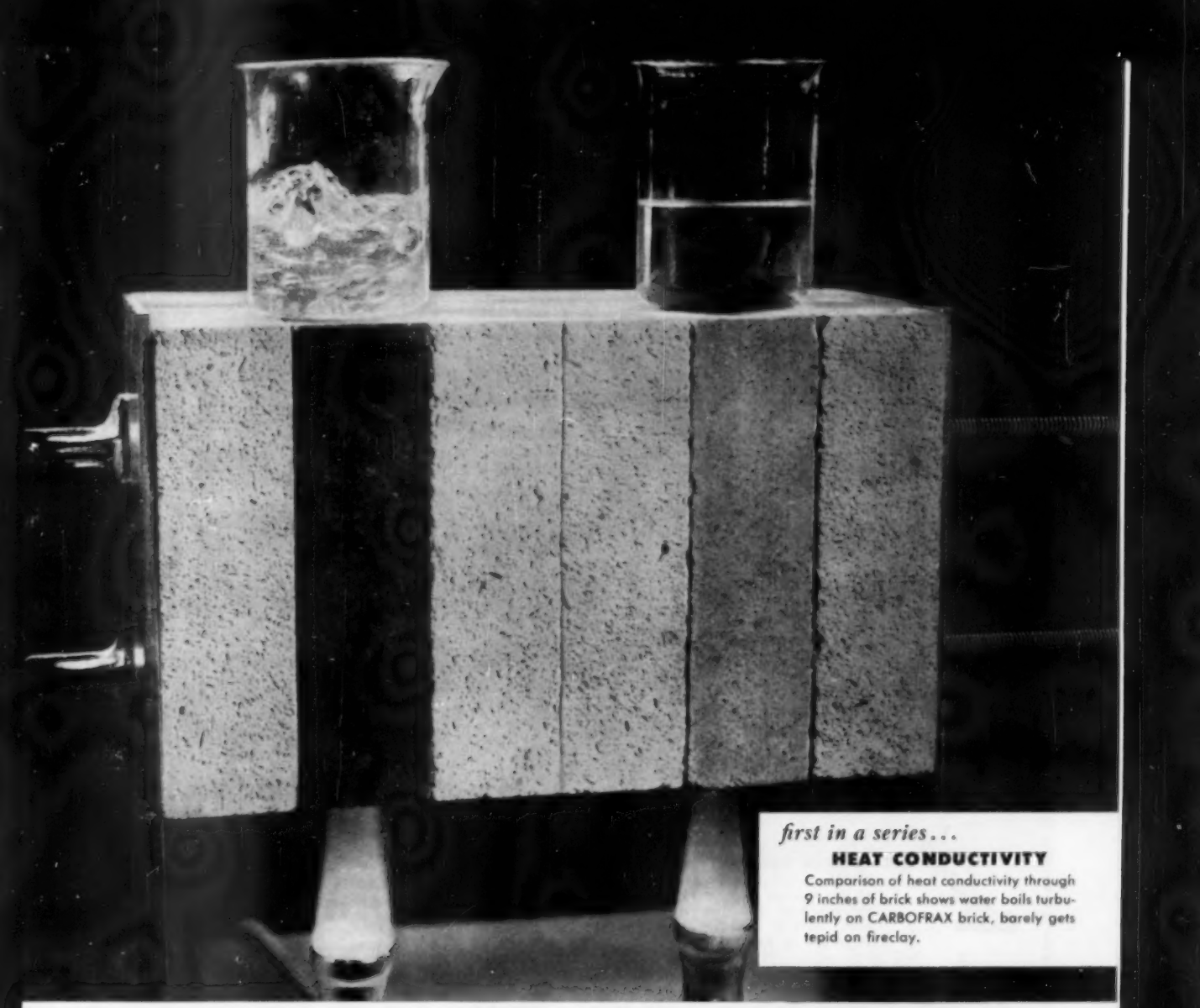
When stationary elements are used the Bayer stationary balanced valve head may be furnished. Thus all the cleaning elements of the entire soot cleaner system can be controlled by the Bayer quick-opening Balanced valves. This gives a uniform or standard valve controlled system and in addition, when high pressures require a reduction in pressure *at each individual element* this Balanced valve unit, whether used with a stationary or a revolving element, can be fitted with an integral orifice plate valve.

Piping connections can be kept in the same plane and undesirable bends or fittings avoided when the Bayer Balanced Valve is installed with both stationary and revolving elements.

Valve parts are standard and interchangeable and when high pressure heads are fitted with orifice plate regulating valves these parts are also interchangeable.

THE BAYER COMPANY

SAINT LOUIS, MISSOURI, U. S. A.



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HEAT CONDUCTIVITY

Comparison of heat conductivity through 9 inches of brick shows water boils turbulently on CARBOFRAX brick, barely gets tepid on fireclay.

Unusual Properties of Refractory Materials

High heat conductivity -- roughly 11 times that of fireclay and about 70% that of chrome-nickel steels -- is one of the properties of CARBOFRAX® silicon carbide refractory brick. It is an ideal material for muffles, radiant tubes, retorts and similar structures where you need exceptional resistance to direct flame *plus* the ability to conduct heat efficiently. At 2200°F, thermal conductivity of CARBOFRAX brick is 109BTU/hr., sq. ft. and °F/in. of thickness.

CARBOFRAX refractories typify the many super refractories pioneered by Carborundum. Each has a wide range of properties. One, for example, is formed into precision parts that look like cast iron yet resist over 3000°F. Another, a new ceramic fiber, filters and insulates at temperatures no existing mineral or glass fiber can take.

Carborundum's new magazine "Refractories" pinpoints many practical applications for these unusual products. The forthcoming issue carries a feature article on "Heat Conductivity". Send for your copy today.

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Please send me the forthcoming issue of "Refractories".

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COMPLETE LINES OF WALWORTH VALVES for POWER PLANT SERVICE

Featuring Walworth Pressure-Seal Valves

Here are cast steel valves built for high-pressure, high-temperature service. The unique bonnet-to-body design utilizes internal line pressure for a tight, leakproof connection. The higher the pressure the tighter the bonnet joint! Bulky, heavy bonnet flanges, bonnet studs, and nuts are completely eliminated providing a modern valve design of truly streamlined proportions. Maintenance is simplified as Walworth Pressure-Seal Valves are easily assembled, disassembled, and insulated.

Walworth Pressure-Seal Valves are available in Series 600, 900, 1500, 2500, and in a wide range of sizes and types. Complete information is available from your nearby Walworth Distributor—or—write Walworth for for a free copy of Circular 16.

and including these valves for "*'round-the-plant*" use!

WALWORTH SMALL CAST STEEL Y-GLOBE VALVES. Simplified design eliminates many of the problems encountered in high-temperature, high-pressure service. No bonnet joint. Improved back-seat design means longer life for packing rings.

WALWORTH LUBRICATED PLUG VALVES. Easy turning—quick operating. Lubricant can be renewed while the valve is in service. Lubricant completely surrounds the plug ports for a tight seal against leaks. Remember, always use Walworth Lubricant in Walworth Lubricated Plug Valves.

WALWORTH BRONZE VALVES. Standardized lines of bronze valves provide an unsurpassed system of interchangeability of parts, drastically reducing inventory problems. Walseal Valves with brazing ends also available in a variety of types.

WALWORTH IRON BODY GATE VALVES. Straight-flow port design reduces fluid turbulence to a practical minimum. Seat rings of end-seated type are screwed into the body. Brass liner on glands assures greater resistance to corrosion and scoring. Available with threaded or flanged ends.

WALWORTH CAST STEEL GATE VALVES. Bolted bonnet, wedge gate, OS&Y. Bonnets and bodies are engineered to withstand pressure and minimize distortion. Heavy steel walls provide extra strength and longer life. Deep stuffing boxes in all sizes (2" to 24") insure tightness and maximum packing life. Also available in globe and angle types.

WALWORTH also offers Plastic Valves, Fittings, and Pipe of polyvinyl chloride, moulded to Walworth's specifications by General American Transportation Company of B. F. Goodrich Chemical Company Geon!

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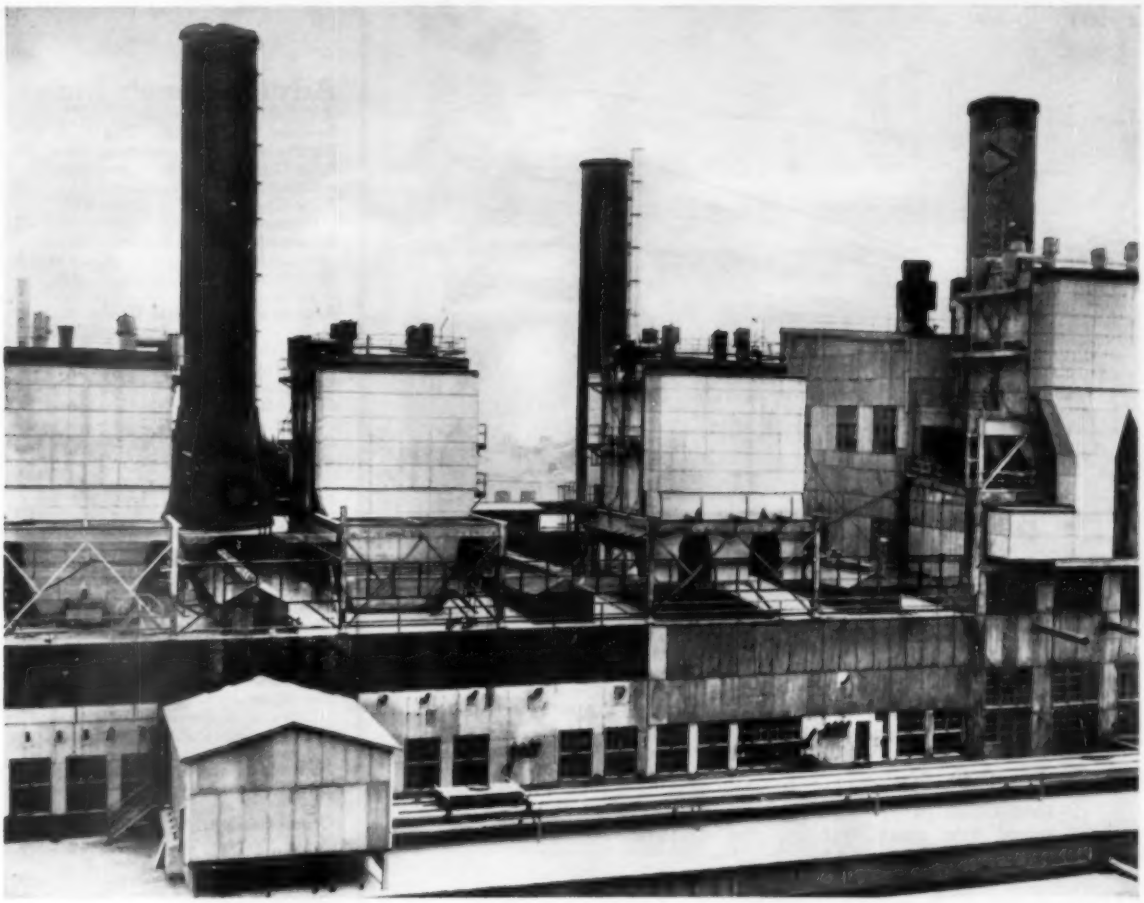

4 Koppers Electrostatic Precipitators exceed guarantee in fly ash removal for Diamond Alkali

Air pollution from the power house is no longer a problem at the world's largest alkali manufacturing plant in Painesville, Ohio. Four Koppers Electrostatic Precipitators atop the boiler house roof at this huge Diamond Alkali plant remove 95% to 97% of the dust normally discharged from the boiler plant stacks.

These Koppers Electrostatic Precipitators went into operation in 1954. Previously, the four plant boilers which vary in capacities—fired with pulverized fuel—had created a nuisance with stack gases containing a high fly ash content. Today, the four Koppers units with a total capacity of over 700,000 cubic feet per minute, trap and remove this fly ash, storing it in collecting hoppers before it is sluiced away to a waste lake.

Koppers engineers determined the most practical and economical precipitator size for each boiler—insuring Diamond Alkali the same high efficiency performance that makes Koppers Electrostatic Precipitators the finest.

If you have a gas cleaning problem, large or small, let Koppers analyze your needs and find the solution. Koppers experience, facilities and service are ready to assist you too. Mail the coupon below for additional information.

KOPPERS®

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE 3, MD. This Koppers Division also supplies industry with Fast's Couplings, American Hammered Industrial Piston and Sealing Rings, Aeromaster Fans, Gas Apparatus.

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FOR WANT OF A NAIL...

Something that wasn't there once cost a king his life.

For today's boiler, lack of internal protective surfacing is hardly a life or death matter. Yet consulting engineers . . . insurance underwriters . . . power plant operators increasingly specify, recommend, and purchase Apexior Number 1 for tube and drum coating. Why?

Because the yardstick of return on investment proves Apexior's unique service *now pays off at the highest rate ever* . . . for modern boiler design and operation today permit a single Apexior application to deliver maximum protection not only for a normally anticipated five years, but for one — three — sometimes even *five years more!*

And because Apexiorizing is now a one-coat procedure, former material and labor estimates are halved. Protection that can last twice as long today costs *half as much* . . . a trifling pennies-per-square-foot premium to insure full return on a major capital investment.

Like the legendary nail, boiler protective coating may seem a factor of small significance — yet it can mean the difference between acceptable performance and the best of which the modern boiler is capable. The assurance every inspection gives that tubes and drums are functioning at new-metal peak efficiency is the measure of Apexior's service in maintaining highest steam production reliability and quality — a contribution measured ultimately in profit dollars.

Internal boiler protection is but one phase of Dampney corrosion-control activity. Dampney Coating Systems for specified end-use service protect cooling towers — intake water structures — pipeline interiors. For a recommendation to meet your requirements, write

MAINTENANCE FOR METAL

THE DAMPNEY COMPANY

HYDE PARK, BOSTON 36, MASSACHUSETTS

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with ABK® METAL

pump life increase—5 to 1

. . . pipe life increase—3 to 1

Pumping 300 tons of ash per day at a large midwestern power plant, pump shells of alloy steel were averaging only six months life. Then pump shells were specified in ABK Metal—a nickel-chrome iron alloy of controlled structure with outstanding abrasion resistance. Installed in 1945, these pumps gave 31 months of service and handled 140,000 tons of ash . . . a pump life increase of over 400%.

In the same installation white iron pipe was formerly used in the ash pipe line . . . lasted no more than 2½ years. ABK pipe, installed in 1945, is still in service in many parts of the line . . . a pipe life increase of over 300%.

For economical handling of your wet or dry ash specify ABK Metal pump casings and impellers, pipes, elbows and fittings, liners, injector nozzles and similar equipment.

1263

American Brake Shoe

BRAKE SHOE AND CASTINGS DIVISION
230 Park Avenue, New York 17, N. Y.

Ultra Modern Headquarters — Metropolitan Edison Company, Reading, Pa.

BRINGING COMFORT TO 600 EMPLOYEES

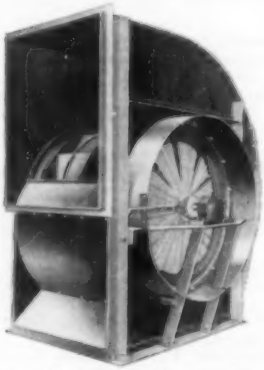
by use of Clarage Equipment with the Heat Pump

Throughout this modern building, containing 190,000 square feet of floor space, air handling is by Clarage equipment.

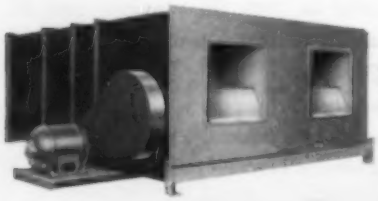
Clarage products shown on the right and below are representative of those selected for Metropolitan Edison's new office and service headquarters.

Here is equipment you can RELY on for trouble-free service and economical operation. Clarage designs and builds for "the long pull" — to stretch your equipment dollar to the utmost.

Recognizing this, the nation's leading engineers, architects, contractors, and building operators are demonstrating a growing preference for Clarage. Call us in for capable assistance on your next requirements. **CLARAGE FAN COMPANY, Kalamazoo, Mich.**



Clarage Type NH fans for ventilating, air conditioning, and various industrial process services.



Clarage Multitherm Units for comfort and process air conditioning applications.

Clarage Unicoil Units—sprayed coil equipment for central station air conditioning systems.

You can Rely on

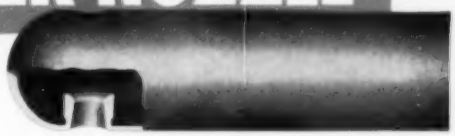
CLARAGE

... dependable equipment for making air your servant

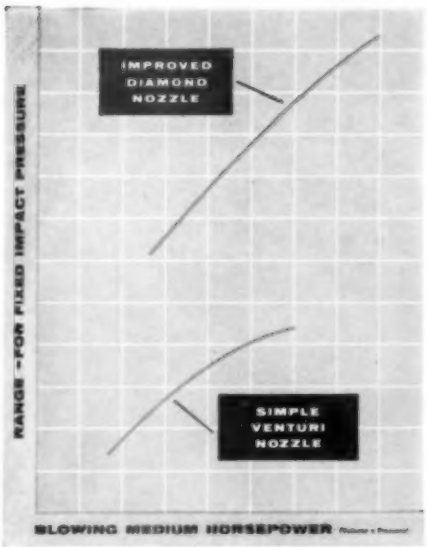
SALES ENGINEERING OFFICES IN ALL PRINCIPAL CITIES • IN CANADA: Canada Fans, Ltd., 4285 Richelieu St., Montreal

GETTING BACK TO FUNDAMENTALS:

Efficient BOILER CLEANING Starts at the BLOWER NOZZLE

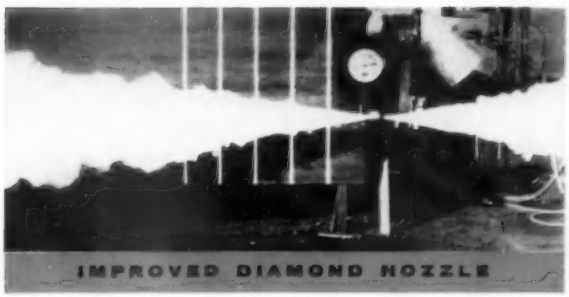


Photograph of section through Diamond "Type A" Nozzle.

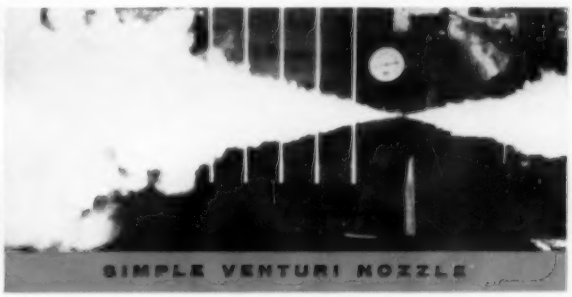


The blower nozzle has the job of converting steam or air pressure into velocity which, in turn, produces impact pressure at the surface to be cleaned. Effective cleaning depends on this impact pressure. A well-designed nozzle will convert much more efficiently . . . doing a better cleaning job with less steam or air.

During the past several years Diamond has conducted intensive research into nozzle design to find the ultimate in efficiency. (More than 50 designs were tested.) It was soon found that nozzle design responds to perfection of detail. Among the details studied were: (1) divergence angle of nozzle, (2) inlet radius as a function of throat diameter, (3) length-diameter ratio of nozzle, (4) area ratio of lance to nozzle throat, and (5) nozzle approach conditions. A product of this research is our new "Type A" Nozzle for Model IK Blowers. The curves at the left show how much more efficient it is than the simple venturi nozzle. The result is improved cleaning at substantially lower energy cost.



IMPROVED DIAMOND NOZZLE



SIMPLE VENTURI NOZZLE

The two photographs above show the Improved Diamond Nozzle and the simple venturi nozzle under identical test conditions. These tests proved that the effective range of the new Diamond nozzle is substantially greater. Also that at the same range, the impact pressure of the Improved Diamond Nozzle is much higher than for the simple nozzle. For equal cleaning ability, the higher efficiency of the new Diamond nozzle requires a much lower blowing medium pressure.

YOU CLEAN BOILERS *BETTER* and at *LOWER COST* with DIAMOND BLOWERS

DIAMOND MODEL IK LONG RETRACTING BLOWER

7271

DIAMOND POWER SPECIALTY CORP. • Lancaster, Ohio

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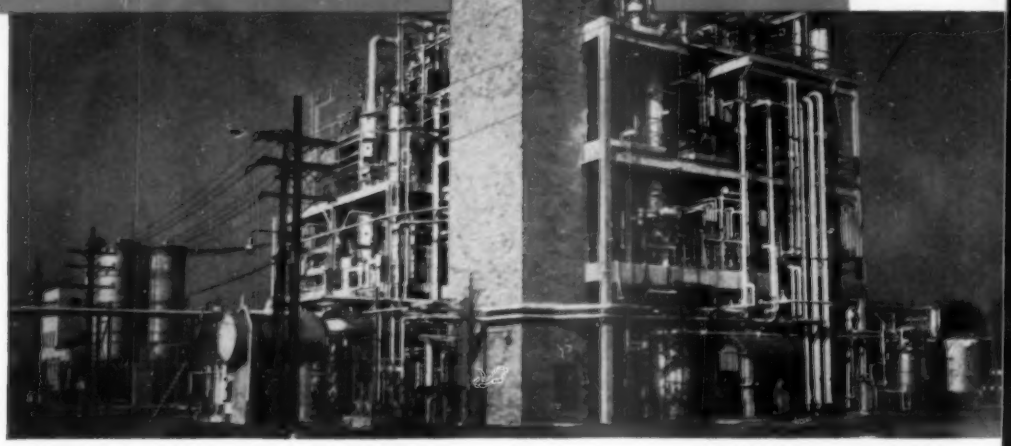
raw material for miracles...



Our association with the Shaw Company has extended over many years in many Hercules plants. The Burlington job is another example of Shaw's ability to fulfill piping contracts—efficiently and on schedule.

Ernest S. Wilson
Director of Engineering
Hercules Powder Company

With the opening of a $4,000,000 plant at Burlington, New Jersey, Hercules Powder Company, of Wilmington, Delaware, recently became a major supplier of dimethyl terephthalate—an important raw material in the miracle fiber field. The Burlington plant—first to produce raw material for polyester fiber by the air oxidation of para xylene produced from petroleum—has a capacity of 12,000,000 pounds of DMT a year, for use in the manufacture of "Terylene," a polyester fiber developed in England. The plant also supplies DMT to various plastics industries.

Because of its vast facilities and extensive experience in fabricating and installing piping for the chemical industry, the Benjamin F. Shaw Company was chosen as piping contractor for the new Hercules plant. The choice proved to be a wise one: the work progressed dependably, skillfully, and, like all Shaw contracts, on schedule. Whatever *your* company produces — from raw materials for miracle fibers to electricity for growing communities—rely on Shaw for a piping job that's first-rate from start to finish.

Main Offices and Plant: Wilmington, Delaware
Piping Fabrication and Installation since 1893

benjamin f. shaw company